POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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Photo. General Electric.

Further Progress in Unnatural History

ONCE AGAIN, after an extended period of somnolence, our Unnatural History Department was suddenly electrified into violent action by the arrival of a photograph from our Chief Unnaturalist, who has been engaged in "field" work around Schenectady. The exact nature of this field work was not disclosed but it is rumored that he had been digging for the W.P.A. Unlike that of another member of our staff, who discovered the skull of the Beloitotherm about a year ago[1] our Chief's veracity is above reproach, but despite this there was some difference of opinion about his claim that this picture showed the petrified carcass of a member of the once powerful but now extinct family Elephantidae Thermodynamica; in fact he went so far as to classify it definitely as a specimen of Elephas Turbinus.

The "yes men" on our staff, as usual, swallowed this story verbatim and were all for running a double page spread in colors, with X marks the spot and everything in the feature section of the Sunday paper until the office boy pointed out that the beast had at least six legs if not more and with his usual delicacy implied that the whole story was just so much "hogwash." "You'se guys is all nertz," he remarked with characteristic but penetrating frankness, "who ever hoid of a member of the Elephantidae genera with more than four legs?"

Our experts took another look, scratched their heads and admitted, finally, that something was wrong; it did appear that the animal had six or eight legs. One member, "a wise guy," thereupon came forth with the brilliant suggestion that maybe this was two Elephas Turbinius, sort of pressed together. This, however, only started an argument, for if there were eight legs, several of the unnaturalists contended that it must be a prehistoric Arameida, a suggestion which met with loud guffaws and hoots from the conservative members of the Department. The Arameida adherents retaliated with shouts of derision, whistles and catcalls together with implications that the Elephantidae protagonists were a gang of ninth-rate imbeciles.

In this democratic and scientific spirit the discussion continued and there is no telling to what profound depths it might have been carried had not somebody—we understand it was the janitor who had come to sweep up—suggested that they read the Chief's letter which had accompanied the photograph. This was dug out of the waste paper basket, where it had been filed, and at once the entire mystery was solved.

The Chief, it seemed, had only been joking and had called the strange creature Elephas Turbinius, merely because it looked like an elephant. As a matter of fact it was nothing of the sort, it was only the outer shell casting of a high pressure steam turbine just removed from the mold at the General Electric shops, before cleaning, trimming or machining. When completed it will be a 40,000-kw. unit.

So, once again, our Unnatural History Department functioned with its characteristic uselessness and after a few final unprintable scientific remarks relapsed into its customary state of lethargy, we hope, for at least another year.

[1] Startling Developments in Unnatural History. p. 204, April 1935 issue.

WITH THE EDITORS

Laboratory Results Available to Engineers

INDUSTRIES have, for many years, recognized that progress and improvement in their products must come, in major portion, as a result of research work directly in their field. No longer can they depend upon haphazard discoveries of inidividual workers to improve established products or develop entirely new products and its application to industry has been so thoroughly panned out that the only hope of discovering something new is by the employment of especially trained research scientists working in a fully equipped laboratory.

Universities of learning were the first to recognize this trend and through this source advances in fundamental principles of science were made almost exclusively until about the turn of the last century when a number of industrial companies established their own laboratories giving especial attention to problems in their field but in many instances discoveries were made that changed the entire course of the company with branches in unrelated fields. Although realizing the advantages of private laboratories, small companies have found the expense too great for their resources and have resorted to the employment of consulting scientists equipped with their own laboratories. In more recent years industrial companies confronted with the same research problem have carried on coöperative work to advantage. Another course followed by some companies is to establish scholarships at universities where the research problems of the industry are studied.

The most recent announcement of coöperative research activities comes from the Welding Research Committee of the Engineering Foundation of which Professor Comfort A. Adams of Harvard University is chairman. A new industrial subcommittee has been formed to coördinate industrial welding research. Sixty investigations are now under way at universities and many more are going forward in industrial and federal laboratories.

Among the institutions which were leaders in the establishing of fellowships is the Mellon Institute of Industrial Research which recently released its twenty-third annual report. In this report it is stated that over 500 new or improved processes and products and nearly 2000 contributions to the literature of pure and applied science have resulted from researches carried on by the Institute. It is noteworthy also that 777 scientists have received training here and entered the fields of manufacturing, commerce and education.

In the power plant field this Institution has contributed valuable information on heat insulation both for low and high temperatures, refractories, use of natural gas, steel and air polution and is still carrying on investigations in these lines.

Purdue University and the University of Illinois both engage in coöperative industrial research with manufacturing concerns and utilities and their contributions to the available technical data are extremely valuable to industry.

The results of investigations carried on in public universities and federal laboratories are made public in bulletin form and through the use of this data the solution to many operating problems, as well as information of aid in making a choice of equipment, may be found. This is a source of information which engineers of power plants confronted with unusual operating difficulties should use to the fullest extent.

Fashions in Fuels

WITH THE abundant supply of coal which has been available in this country, little consideration was given, except in specific localities, to the use of any other natural fuel for the generation of steam and power until the advent of the World War. Economic conditions were such at that time that great stress was laid upon economy in the use of fuel. This brought on not only the development of more efficient equipment for burning coal but fostered a study of the possibilities of using other fuels for power purposes. As a rule, decisions have been based on the cost in dollars and cents of the fuel for generating steam, although other factors such as plant and community cleanliness, air polution, and transportation convenience have entered into the problem.

So narrow is the margin of advantage of one fuel over another in many industrial centers, that a slight change in price ratio often makes a change in fuel advantageous. Coal, oil and gas now come in for direct competition, with a decision necessary in power plants from season to season. A recent check up on boiler plants in Chicago revealed that approximately 10 per cent are now using oil as fuel. Due to a reduction in the price of gas during summer months, this fuel will have a seasonal demand in many plants.

To be able to shift from one fuel to another without prohibitive expense for changes was for many years a perplexing problem which has been solved in some plants by the installation of combination burners suitable for burning powdered coal, oil or gas, either separately or in any desired combination. Stoker fired furnaces have also been designed for inexpensive and rapid change to oil or gas, so that a plant need no longer be bound to its original choice of fuel but may take advantage of price changes as they may occur.

Not only are the solid, liquid and gaseous fuels competing with each other for the boiler plant market but coals themselves are being modified by manufacturing methods so that there are available not only sized coals but those that have been washed, hand picked or oil treated to meet the fancies of a fastidious and economically minded public. Engineers have not as yet come to that point of fashion that demands a distinct choice of fuel for mornings, afternoons and nights but there is much to be said in favor selecting fuels for their economic value in the specific plant in which they are to be used.

KAPLAN TURBINES Meet

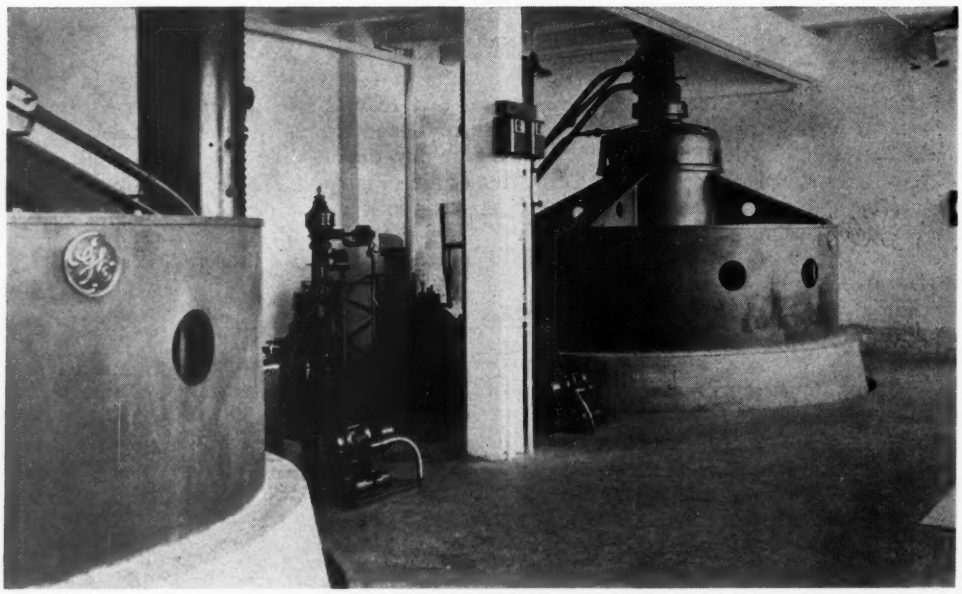
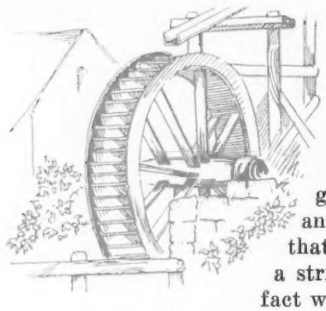


Fig. 1. The two new Kaplan Turbine Generating Units



AS HAS FREQUENTLY been pointed out in these columns, the rehabilitation of an existing plant often involves greater engineering skill and resourcefulness than that ordinarily required in a strictly new project. This fact was very apparent in the case of a rehabilitation project which we recently had the opportunity of studying—that of the Chemical Paper Manufacturing Co. at Holyoke, Massachusetts, where ten water wheels of rather ancient vintage were replaced by a new power generating installation consisting of two Kaplan turbine generating units. The problems involved in effecting such a change need scarcely be pointed out to anybody even remotely familiar with the general character of the old time New England mill; it required not only the replacement of obsolete equipment with new, but a general rehabilitation of a large part of the paper mill itself, including the electrification of a certain amount of mill equipment which formerly had been mechanically driven. Furthermore, economic considerations demanded the use of as much of the existing electrical equipment in the new layout as possible, and finally, all the work had to be done with the plant in full operation and with no loss of production.

The story of how all this was accomplished is an interesting one and can really only be told by Ralph Bosworth, the plant engineer of the Chemical Paper Manufacturing Co., under whose direction the work was carried out. However, in this article we shall endeavor to present an account of the more important aspects of the work.

Water Power System at Holyoke

To begin with, one should have some idea of the water power system in Holyoke. This is best explained by means of the small map in Fig. 2. As shown, a head of water is obtained by means of the dam constructed across the Connecticut River between Holyoke and South Hadley. Water from above this dam flows into what has grown to be quite an elaborate system of canals from which all the plants in the city using water power take their water supply. There are three canal levels, known as First, Second and Third Levels, respectively. The First Level is maintained at approximately 101 (the dam is 100). Plants located between the First and Second Levels utilize the head of water which normally exists between those two canals (approximately 20 ft.). Plants between the Second and Third Levels use the head between those two (again approximately 20 ft.) and finally plants located between the Third Level and the river utilize that final portion of the total drop.

The plant of the Chemical Paper Manufacturing Co. is one of the latter plants, that is it is situated between the third level canal and the river. The normal level of the water in the third level canal is 67 ft. Since the lower river level varies from 41 to 67 ft. (75 during the flood of 1936), it is evident that the hydraulic installation is subject to a wide variation in head, a factor which had much to do with the selection of the Kaplan turbine installed. Under normal conditions the available head of water is considered 22 ft.

The present water power development consists of

Variable Head Requirements at Holyoke Paper Plant

New Hydroelectric Generating Plant at the mill of the Chemical Paper Manufacturing Co. at Holyoke, Massachusetts, replaces an old installation consisting of ten water wheels mechanically connected to the paper making machinery. The head varies between 41 and 61 ft., a fact which determined the selection of the Kaplan Automatically Adjustable Propeller type units.

a rack built in the third level canal in 1925 which is amply large to give low velocities of water through it; a head race which consists of mud sills and plank floors on which are built brick walls with two brick arches under the road and railway tracks at the west side of the plant and a stone wall with a single line of columns down the center supporting the second floor of the building as far as the wheel pit; a wheel pit, also on mud sills and a plank floor with stone walls supporting the floor and building above it, and finally, a tail race on mud sills and a plank floor with walls of brick, the latter forming a double arch to the river.

Old Arrangement

Originally, as has been mentioned, power was produced by ten separate water wheels all installed in one wooden open flume. The manner in which these wheels were used is shown in Fig. 3, although here only eight wheels are actually shown since one of them had been wrecked and another disconnected in 1930. These eight wheels were mechanically connected to the beaters in the paper mill as shown. Wheels E, C and A were belted to one set of beaters and also to a 312 hp., 600 r.p.m. generator (No. 04). Wheel R was coupled to a second set of beaters. Wheel L drove a third set of beaters and R and L lines both belted to a countershaft driving a 200 hp. 600 r.p.m. generator (No. 02). Wheels M and P were belted to a 225 hp., 900 r.p.m. generator (No. 03) and finally wheel G drove a 200 hp., 600 r.p.m. generator (No. 05) thru a quarter turn belt.

Generator No. 02 and 04 were provided with amortisseur windings and during times of high water in the river served as motors to maintain uniform speed on the beater lines using purchased electric power.

These drives, it can readily be understood, involved a considerable amount of line shafting together with many belts and pulleys and from a modern viewpoint, though they had served well, were unsatisfactory from both an operating as well as an economic standpoint. There was also a steam driven generating unit, a 550 kw. Corliss engine unit shown in Fig. 3 as No. 06. This steam driven unit as well as the other generators mentioned were tied in with an outside source of power.

After careful consideration, it finally was decided to electrify all the beaters and to replace the existing water wheels with modern hydraulic turbine generating units. From observation, it had been estimated that the output of the old water wheels totaled about 836 kw., average. It was also estimated that the output of the new units would be around 1140 kw.

Several possibilities had been considered, first a single unit, next two 75 in. turbines and finally four Francis type units. In view of the widely varying head under which the plant would have to operate, there was finally no alternative but to decide upon two 75 in. adjustable blade Kaplan turbines. These machines, it was found, would give a much higher efficiency over a much wider range of head than any other type of unit available.

Kaplan Turbines Installed

Accordingly, two such units were installed in the same space formerly occupied by the ten old water

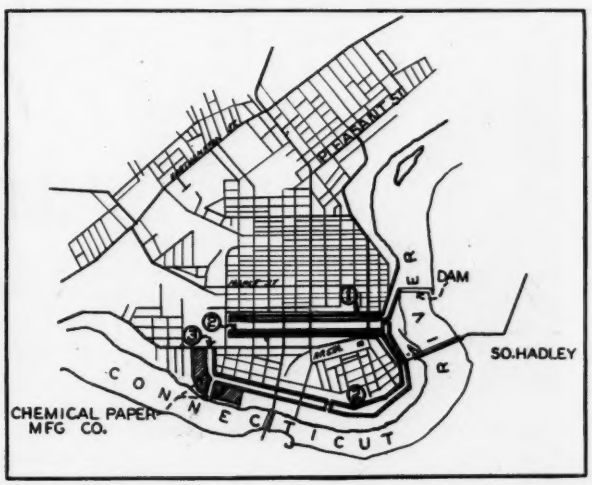


Fig. 2. Map of the city of Holyoke, Mass., showing the canal system providing water power service

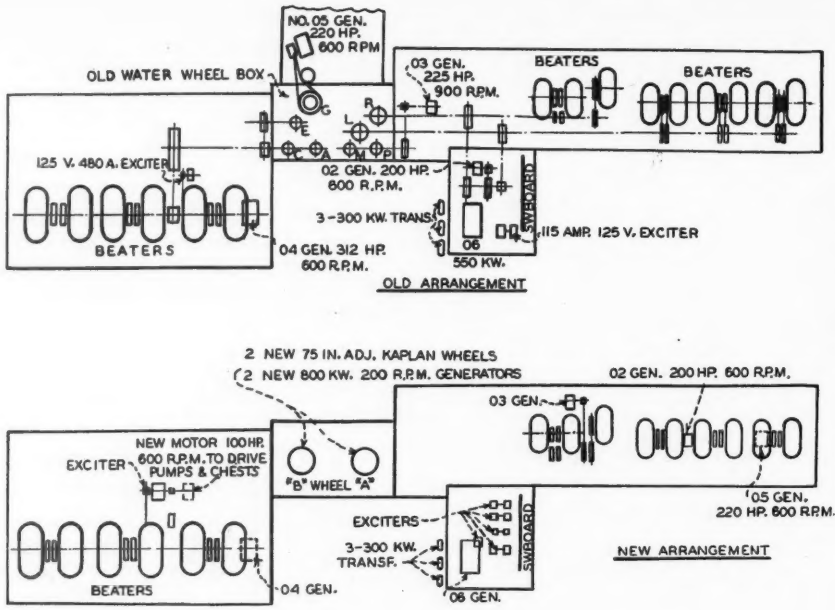


Fig. 3. Diagram showing the old and new arrangements. Above is shown the old arrangement consisting of eight water wheels mechanically connected to the beaters in the paper plant. Below is shown the present arrangement. The beaters have been electrified and the eight water wheels have been replaced by two Kaplan turbine generating units

wheels. They were manufactured by S. Morgan Smith and are of the automatically adjustable propeller type, one right handed and the other left handed with concrete spiral casings and steel elbow type draft tube. Each unit is equipped with an 18,000 lb. Lombard governor.

These turbines are set side by side as shown in the accompanying photographs and drawings and drive two 1000 kv-a. 200 r.p.m., 600 v., 3 phase, 60 cycle

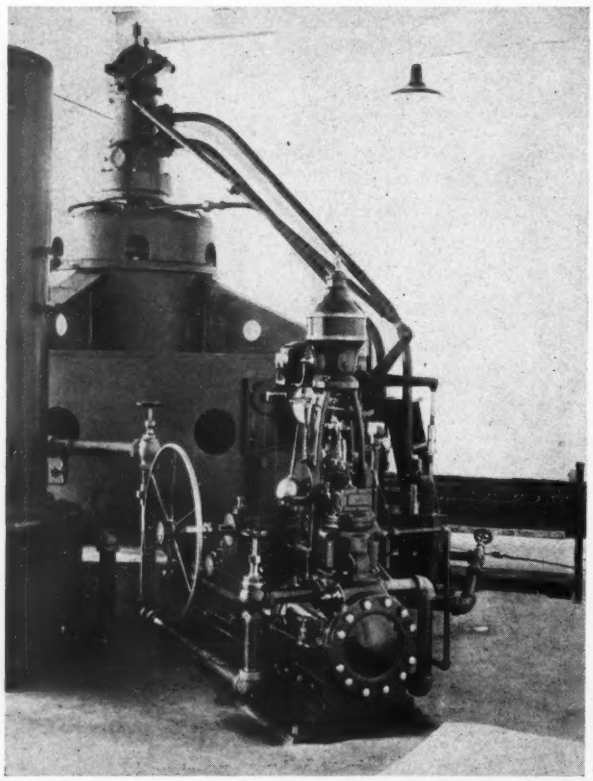


Fig. 4. Each turbine is governed by an 18,000 ft. lb. Lombard governor

General Electric generators, each equipped with a thrust bearing and two guide bearings. Because of the limited headroom, direct connected exciters were not feasible; hence, separate motor driven exciters are provided. These are installed in the old engine room.

Old Generators Now Used as Motors

The installation of the new generating units naturally released the four old generators from service, and made it possible to use these machines as synchronous motors for driving the beaters. These were rearranged as shown in Fig. 3 (below). In addition to the existing motors, a new 100 hp., 600 r.p.m. motor was purchased to drive the chests and pumps associated with the beaters.

Naturally there were many problems involved in making these changes. The buildings were old and there was much cutting of walls necessary. Concrete scroll cases and steel draft tubes were installed for the Kaplan turbines. Line shafting had to be removed, motors remounted, conduits run and feeder circuits designed and installed and all this had to be done without loss of production. One generator was installed at a time.

The detailed arrangement of the final plant is shown in Fig. C, which accurately shows the relation between the hydraulic turbine units, the beater drives and the steam power plant. All switching is done at the main switchboard in the engine room. The conduit runs between the main generators and the switchboard and are simple, direct and easily accessible. They are laid in a steel trench which is covered by removable floor plates.

Steam Plant Not Altered

The steam plant was not altered materially. It consists of three boilers together with a 24 by 36 in. Allis-Chalmers simple Corliss valve engine, operating at 150 r.p.m. on 120 lb. initial pressure and against 20 lb. back pressure. The unit in fact is operated under back pressure control to supply the necessary steam for drying and heating. It is direct connected to a 550 kw.,

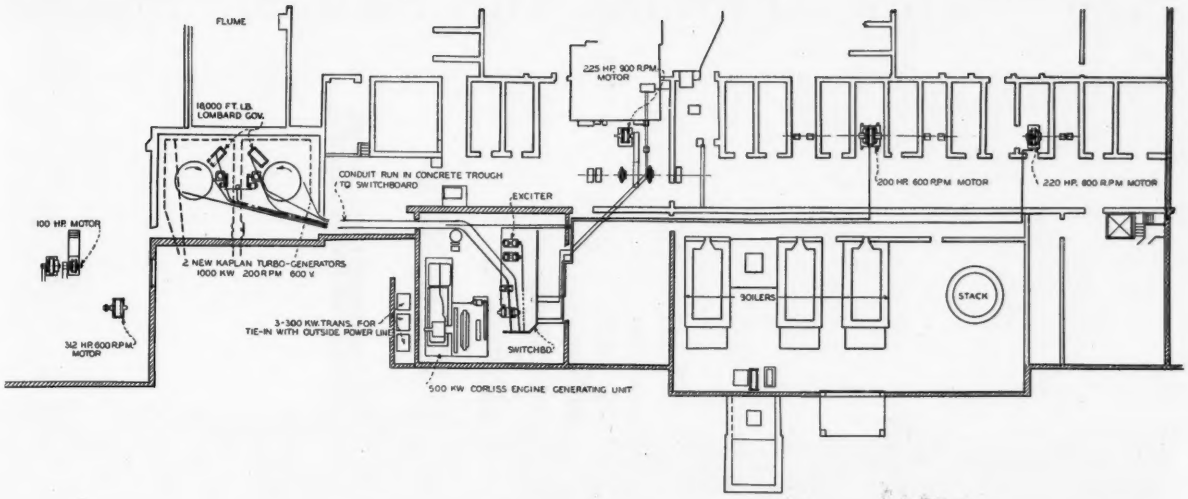

FLUME
18000 FT. LB. LOMBARD GOV.
225 HP. 900 R.P.M. MOTOR
CONDUIT RUN IN CONCRETE TROUGH TO SWITCHBOARD
EXCITER
200 HP. 600 R.P.M. MOTOR
220 HP. 600 R.P.M. MOTOR
100 HP. MOTOR
2 NEW KAPLAN TURBO-GENERATORS 1000 KW. 200 R.P.M. 600 V.
BOILERS
STACK
3-300 KW. TRANS. FOR TIE-IN WITH OUTSIDE POWER LINE
342 HP. 600 R.P.M. MOTOR
SWITCHBD.
500 KW. CORLISS ENGINE GENERATING UNIT

Fig. 5. Diagram showing details of the new plant

80 per cent power factor, 600 v., 3 phase, 60 cycle Allis-Chalmers generator with belted exciter. This unit was installed in 1930 with the re-development of the box-board mill. The unit is tied in with an outside source of power floating on the line at all times. This is a 4600 v. line and the interconnection is made through a bank of three 300 kv-a. transformers.

The boiler room is located as shown. The principal equipment there consists of three H.R.T. 96 in. diameter boilers with Coxe chain grate stokers driven by motors. These units are normally operated at 200 per cent rating, all three units being used in winter but only two during the summer. Coal used in anthracite screenings (bird's eye) of about 12,500 B.t.u. as received. Normally, an efficiency of about 64 per cent is maintained.

One Buffalo Forge Co. fan supplies forced draft. This is a 120 in. steel plate blower having a capacity of 23,000 c.f.m. at 4 in. water gage when operating at 325 r. p. m. The fan takes air from the upper part of the boiler room and delivers it to concrete ducts under the floor which in turn connect with the stoker windboxes. The windbox control is by hand but the fan is controlled from the steam pressure. A 9 ft. diam., 150 ft. high stack is provided.

Feedwater is taken directly from the city mains and is not treated.

This briefly describes the nature of the changes made at the Chemical Paper Manufacturing Co. at Holyoke. Needless to say this new arrangement of hydraulic generators and electric drives has proved highly satisfactory and well worth while from a power saving standpoint.

The Kaplan units have operated efficiently under widely varying heads and without trouble. The guaranteed efficiency of these units at their best point, i.e. at 1000 kw., is 91.5 per cent, but the efficiency curve is substantially flat over the range from 500 to 1000 kw.

A cross section through one of the new units is shown in Fig. 6. This shows the construction of the wheel casing and the draft tube and also the location of the equipment with respect to the building proper.

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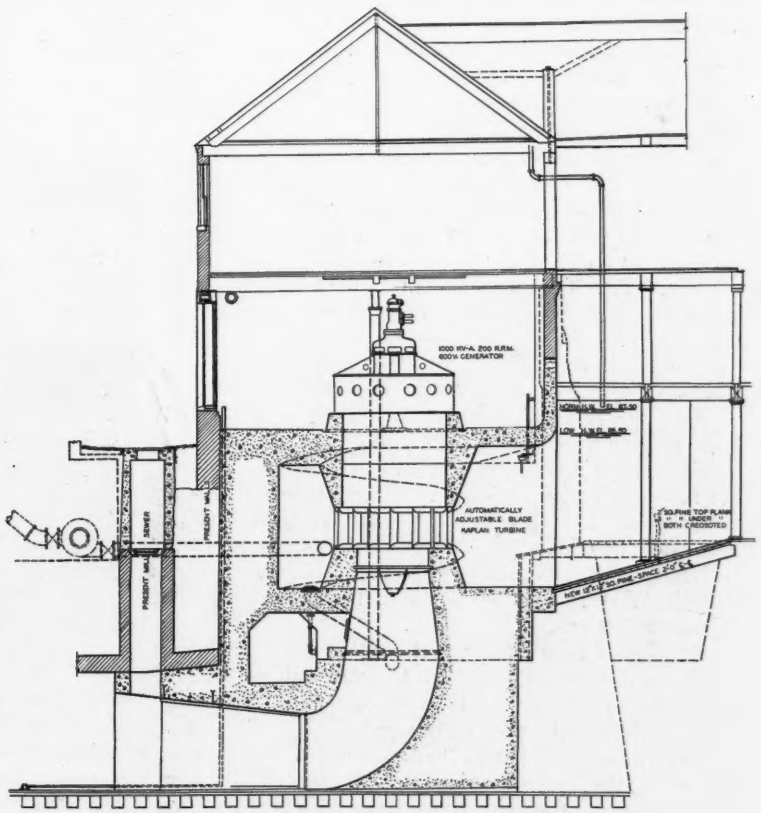
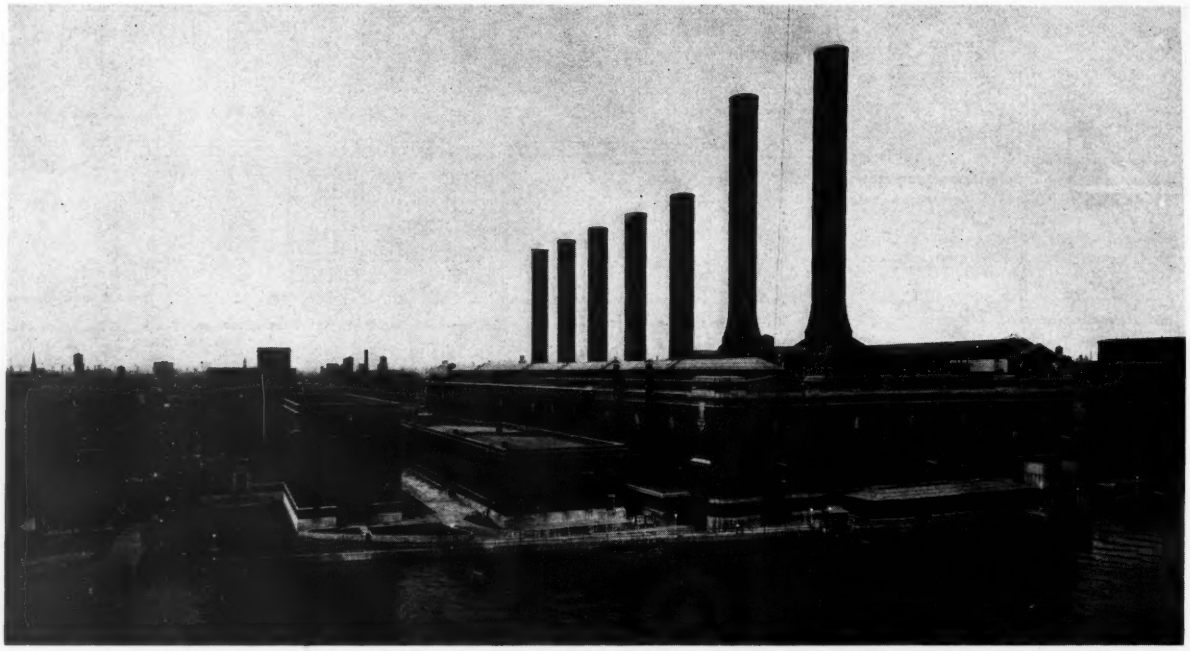


Fig. 6. Sectional view of one of the generating units

New "Top" Turbine for Fisk St. Station



THE COMMONWEALTH EDISON CO. of Chicago has made announcement of a modernization program to cost $3,000,000 for Fisk Street Generating Station. Construction of the new equipment and changes in the station structure are expected to take eighteen months.

Improvements to be made include two new boilers, to replace 16 old boilers, and the installation of a new high pressure turbine rated at 30,000 kw. The old boilers were installed in 1909.

The new boilers will be fired by pulverized coal and will operate at 1200 lb. pressure. The present boilers operate at 250 lb. pressure. The 1200 lb. high pressure turbine will exhaust into two of the present low pressure turbines, one of 25,000 and the other of 35,000 kw. capacity. Thus the entire installation will have a total capacity of 90,000 kw. Contract for the turbine has been awarded to the Allis-Chalmers Mfg. Co. while The Babcock and Wilcox Co. has been awarded the contract for the construction of the new boilers.

Fisk Street Station which is located at 22nd and Fisk Streets was built in 1903 and was the first all steam-turbine generating station in the world. Due to the foresight and confidence of Samuel Insull, it was in this station that the first 5000 kw. vertical turbine generator was installed. While this was not the first turbine installation it was the first unit of such high capacity and it marked the actual beginning of the steam turbine era.

Since that time Fisk Street Station has undergone many changes as old equipment wore out or became obsolete and improvements were made in generating units, boilers and other equipment.

Growth of the station had reached a limit years ago when the federal government restricted the flow of water in the Chicago River, since that is the source of the condensing water supply. Because of the recent development of high pressure equipment, that is, the use of the "top" turbine, it is now possible to increase the station capacity without increasing the amount of water taken from the river for condensing purposes.

Because of its proximity to the downtown business center of Chicago, Fisk Street Station is an important element in the Commonwealth Edison system.

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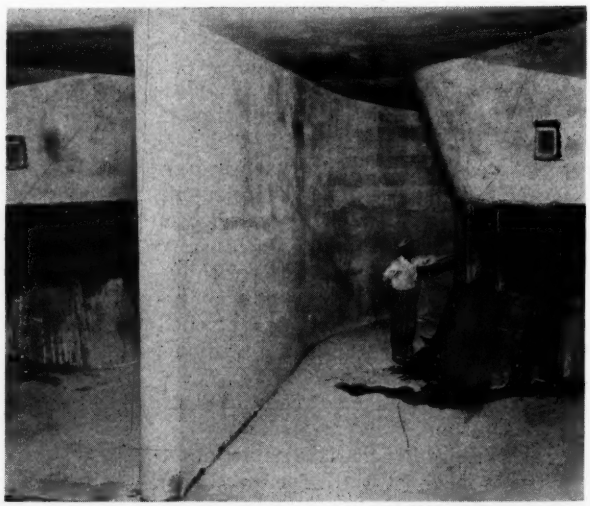


Fig. 7. Interior view of the concrete scroll casings

As pointed out before, the work was done entirely under the direction and supervision of Ralph L. Bosworth, plant engineer of the Chemical Paper Manufacturing Co., to whom we are indebted for the privilege of presenting this description, and for the drawings shown.

FURNACE EQUIPMENT *and* POWER PLANT ECONOMY

Trends toward large high-pressure boiler units, for continuous operation, emphasizes necessity of furnace equipment that can operate almost indefinitely without outages.

By M. K. Drewry*

The Milwaukee Electric Ry. & Lt. Co.
Milwaukee, Wis.

WHAT STOPS BOILER-UNITS is a question receiving much attention at present, because operators realize that economy is often most affected by unavailability of otherwise inherently efficient equipment. The need of periodic furnace cleanings, occurrence of water wall failures, or replacement of stoker parts, for instance, can subtract as much from integrated savings of new equipment as the failure to attain expected high temperatures or inherently high efficiencies.

Someone has said that new boiler-units should be idle only once a year, and then only for inspection. Were this an actuality, important savings could be made in first costs and operating expenses by making extensions with single large units. That boiler units can almost attain the afore-mentioned specification of one stop per year is indicated by the 5 yr. data of four large high pressure boilers operating at high load factor. Experience proves that at least three of the units can be operated indefinitely without outages in any way caused by furnace equipment. In the earliest unit, ash forms on inaccessible brick-work in furnace corners when using Mid-western coal. In none, is slagging of the boiler tubes scarcely more than incidental when burning various mixtures of West Kentucky and Illinois coals with 2050 to 2200 deg. F. ash fusion temperatures, with 22 per cent excess air.

Overall station results in which the same type furnace is used seem to indicate that furnace design favorable to economy is helpful in actual practice. For four consecutive months of initial operation the station has averaged 11,412 B.t.u. per kw-hr. net. Both superheat and reheat temperatures are practically constant at 820 deg. F. throughout a load range of 20,000 to 80,000 kw. in spite of reheater inlet steam (from the turbine) coincidently increasing 100 deg. F. The furnace design contributes appreciably to the above reported economy.

Experience with three units prove that a real basis exists for permitting the selection of large, single, boiler units; that furnace equipment is now available that keeps new, efficient equipment in service to attain maximum economy.

Excess Air Reduction

CO_2 of 17 per cent, corresponding to approximately 10 per cent excess air, has often been observed in pulverized coal installations without presence of CO losses. Many boiler units are now operating with 15 per cent excess air (about 16 per cent CO_2) while 10 per cent excess air average seems practical for those few units in which air leakage is limited to a few per cent.

Use of large air heaters has prompted curtailment of air leakage, because air heater performance suffers rapidly from cooling-air shortages. In one case, 10 per cent less air through the heater increases flue gas temperatures 30 deg. F., thus causing nearly 1 per cent additional stack loss, plus another loss of similar magnitude if leakage air is of no assistance in the combustion process. Ten per cent total air leakage has been averaged by four large units for several years. Another more recent unit experiences less than 5 per cent air leakage. Making modern units practically pressure-tight will assist in attaining the next goal of 10 per cent excess air.

That temperature differences of pulverized fuel furnaces have slight effect upon combustion rate is deduced from a comprehensive research study. The combustion rate scarcely increases proportionately with temperature in actual furnaces. Considering that time for combustion varies inversely with temperature (due to higher specific volume of furnace gases) the conclusion can be drawn that in typical furnaces, combustion

*The Milwaukee Electric Railway & Light Co. Abstract of a paper presented at the Midwest Power Engineering Conference, Chicago, April 23, 1936.

completeness is approximately independent of temperature. Higher temperatures than 2000 deg. F. are more likely to decrease combustion efficiency than to increase it.

Superheat Temperature Uniformity

Because superheater duty is growing rapidly, and boiler duty is lessening almost as steadily, furnace equipment will play an increasingly important role in plant economy, and reliability as well. The furnaces finally being recognized responsible for much superheater misbehavior. Superheaters can no longer be considered as minor boiler auxiliaries and their performance simply a function of previous boiler-surface heat absorption. Furnace heat absorption is now a vital variable controlling maintenance of proper superheat temperatures.

Higher steam temperatures accentuate the need of more uniform steam temperature regulation, for bolting and other highly stressed parts become relatively weak. A 100 deg. F. temperature difference of component low-carbon steel parts causes stress of 20,000 lb. per sq. in. as which added to initial stresses can cause leakage, shut-down, and economy loss. 1200 lb. steam requires 170 deg. F. superheat for 750 deg. F. steam temperature, and twice as much for 920 deg. F. steam, a 20 per cent superheater performance change causes 46 deg. F. variation in the first case, and 84 deg. F. in the second. If 20 per cent variation is maximum permissible at 750 deg. F., five per cent variation, causing 20 deg. F. fluctuation, represents equivalent desirable practice at 900 deg. F. Thus, temperature control must improve greatly (several times) as higher temperatures are used.

Ash Coatings

Variations in furnace heat absorption due to variable ash coatings on furnace tubes can affect plant economy adversely. Deposits for one load are unsatisfactory for another, and excess air requirements for one fuel can readily cause undesirable steam temperatures with another fuel. Proper thickness coatings are not built in an hour, or even a day, and are sometimes lost when banking or when overheating the furnace for slag-tapping under adverse circumstances. The operator must anticipate future load and fuel conditions, a procedure which often cannot and is not done. Mixing of two or more different fuels to take advantage of existing coal markets will become increasingly difficult unless furnace equipment is carefully chosen.

Regulation of Steam Temperature

De-superheating at all loads above half-load, adjusting superheater by-pass baffles, and otherwise changing gas flow rates appear temporary compromises when examined for their practicability in the future plant. It seems obvious that when superheater duty equals boiler duty that surfaces of each must be similarly disposed in both the furnace and the convection bank. Under these conditions, regulation problems will be much easier of solution.

Use a radiant superheaters for high steam temperatures will require moderate rates of heat transfer. High alloy tubes, with low thermal conductance and high thermal expansion are unfortunately poorer than carbon steel tubes in regard to heat flow characteristics. They tend to warp when used on furnace walls, their welds fail unless well made, and their total expansion presents structural problems. Transfer rates in excess of 75,000 B.t.u. per hr. per sq. ft., corresponding to nearby furnace temperature of about 2300 deg. F., are probably impractical. Decreasing superheater transfer with insulating surfaces also appears impractical, considering their variable-insulating affect as they collect various thickness ash coatings.

Whether furnace temperatures should be above or below the ash melting point (which varies a few hundred degrees above the fusion temperature) appears a major question at present. What relative economy aspects have the two methods? The following tabulation catalogues their design and operating characteristics:

	Dry Ash	Molten Ash
Furnace type		
Typical av. temp. deg. F.	2100	2600
Furnace design		
Size, relatively	Large	Small
Water walls	Bare	Insulated
Bottom	Hopper-type	Flat
Ash removal	Manual or hydraulic	By tapping
Ash storage space screened	Yes	No
Heat transfer rates		
To bare cooled surfaces, B.t.u. per hr. per sq. ft.	50,000	125,000
Per cent of heat in coal absorbed		
In furnace	50	30
Ash conditions		
At furnace bottom		
Normal outputs	Dust and particles	Fluid
Low outputs	Dry dust	Solid
On furnace walls	Fragile accumulations	Thick lava-like fluid
At boiler entrance and superheater		
Normal outputs	Dry dust and fragile accumulations	Tenacious deposit
Low outputs	Dry dust	Fragile deposit
Superheat temperature regulation		
Affect of variable furnace cleanliness	Slight	Greater

Transition from the wet to the dry ash state at various points in the furnace, boiler or superheating equipment, depending upon load, coal type, excess air, flame position, and other variables, compared with maintenance of dry ash under all conditions, appears the important difference in the two furnace types. Could this transition always faithfully occur in a large cooling space previous to the boiler entrance, then maintenance of uniform superheater temperatures would seem more practical. Of necessity this cooling space would be so large that size economy of the boiler-unit would be largely lost.

Radiant Heat Absorption

Particles of burning coal in a typical furnace emit three-quarters of the radiant heat, leaving one-quarter for non-luminous gas radiation. Direct absorption of heat from the burning fuel particles rather than indirect absorption after heating the products of combustion to higher temperatures in furnaces with insulated water walls, seems more conducive of economy.

Since no radiation occurs from nitrogen, which comprises 80 per cent of the products of combustion, the practice of furnace water-wall insulation renders heat of combustion more difficult of absorption by causing it to become stored in gases that surrender it only by relatively ineffective convection heat transfer. At 2000 deg. F. and normal boiler-entrance conditions, radiant heat transfer rate is approximately 20 times that of convection transfer.

Thick layers of gases and thick clouds of burning

coal particles are necessary for highest radiant heat transfer rates at any given temperature. Taking advantage of thick layers in the furnace by covering all wall space with bare heat-absorbing tubes seems most efficient. Radiant heating in nests of boiler tubes is low because of thin gas strata and absence of burning fuel particles.

Furnace Versatility

Most versatile of all power plant equipment, must be the modern furnace. Changeable coal markets require that it burn coals with important differences in volatile content and ash characteristics, at various loads, and without affecting the performance of other equipment.

Ash softening temperatures of American coals vary from 1900 to over 3000 deg. F. Actual average furnace temperatures at normal loads vary from 2000 to about 2600 deg. F. depending upon the amount of radiant heat absorbed from the furnace.

Flame temperatures, without any furnace radiant heat absorption and with normal excess air, would vary from 3000 deg. F. to 3500 deg. F. After considering that average furnace temperatures actually vary almost linearly with load, one realizes the almost infinite number of temperature combinations causing acceptable or unsatisfactory ash conditions.

While coping with the ash problem, the furnace must deliver definite quantities of heat to the boiler and superheater, for it is largely responsible for costly variations in steam temperature. It must burn widely different kinds of fuel with low excess air, yet with little combustible loss.

Only by a careful cost estimate of the multitude of operating and investment costs affected by furnace design can an intelligent selection of best furnace equipment for a given installation be made. To make this careful cost estimate reliable, much test data and many actual operating costs must be available from past experience.

Critical examination of power plant economy will indicate that the furnace is the proper starting point of the economy search, that its best design is extremely involved because of being affected by so many variables, and that it will become increasingly important in the economy of new higher temperature plants.

Developments in the Direct-Current Transformer

THE DIRECT-CURRENT transformer has come down through the years in such company as the left-handed monkey wrench, the key to the flagpole, the nickel's worth of radium, and the various other gadgets, in search of which novice engineers, new apprentices and office boys have gone on all-day searches. Now, however, the direct-current transformer must be removed from that category, according to Dr. A. W. Hull, assistant director of the General Electric research laboratory, who described a direct-current transformer in an address before the National Academy of Sciences, in Washington on April 27.

Today, the d.c. transformer is no longer a practical joke. Thanks to the thyratron tube, it is a device which will have practical application in the not-too-far-distant future, Dr. Hull said.

The thyratron is a gaseous-discharge rectifier tube containing a grid which controls the starting of the discharge current. Two or more thyratrons, used with a transformer, accomplish the feat of changing direct current into alternating. Thus direct current can be transformed in the laboratory with almost as great facility as alternating.

While this has been known for some time, engineers have hesitated to take advantage of it because of the new and untried features involved, but many of these unknowns have now been changed to known in the Research Laboratory of the General Electric Company, Dr. Hull reported.

In these studies it was found that the problem could be greatly simplified by using electric circuits which maintain *constant current* in the line, allowing the voltage, rather than the current, to vary with load. A short-circuit under these conditions reduces the flow of power, and does no harm to either tubes or circuit. This type of circuit not only facilitates research, by making it permissible to produce failures at will in order to study their effects, but also has advantages which will prove of value when commercial applications become possible in the future.

An extensive study has been made of the mutual effects of tubes and circuit. One of the most important discoveries is a circuit condition such that inverter tubes will immediately resume operation, generally within one cycle, after a failure of either tubes or circuit.

Circuit conditions for high-voltage operation have been investigated, Dr. Hull said. It is found that the maximum voltage at which tubes will operate is inversely proportional to the current which they will carry. Rectifier units using 12 phanotron tubes, rectifier tubes of the hot-cathode, mercury vapor type, are required to change 200 amp. of alternating current to 200 amp. direct current at 30,000 v.; and similiar units using 12 thyratron tubes to change it back to alternating current. The tests indicate that the voltage of this unit may be doubled, trebled, etc. by using two, three, etc. tubes in series in place of each single tube in the unit; and that the units themselves may be connected to give any desired voltage.

The life of the thyratron tubes has been found to depend upon the circuit, which determines the velocity, and hence the destructiveness, of impacts of positive ions upon the anode. Circuit conditions have been found which minimize this effect, and promise a tube life of adequate length, Dr. Hull, concluded.

Reduced Vs. Extracted Steam

In The Question answered on page 252 of the April 1936 issue, the heat content of 230 deg. F. water was used as 368.14 instead of 198.15 B.t.u. per lb. Making the numerical corrections necessary, the amount of water required by the desuperheater is reduced to 15,700. Other values are changed slightly and the potential power as given in the last paragraph of the second question is reduced from 32 to about 30 kw. hr. per thousand pounds of steam.

PART XVI. The jet pipe system of the Askania Regulator Co., utilizing a master air impulse in conjunction with oil operated regulators.

COMBUSTION CONTROL

DUE TO VARIATIONS in plant design and methods of firing, a control system must be sufficiently flexible to meet the needs of an infinite variety of plants. Previously, articles have shown the application of control to pulverized fuel and underfeed stoker firing while this article shows the application to a chain grate stoker in an unusually interesting arrangement.

The Askania system is built around the jet-pipe shown diagrammatically by Fig. 1. The jet pipe is pivoted and swings horizontally so that a jet of oil impinges equally or unequally on adjacent orifices. When displaced from its neutral position a differential pressure is created which moves operating pistons. The jet is moved in a number of ways, by a pivoted weigh beam, diaphragm, expansion thermometer or solenoid as necessitated by specific applications.

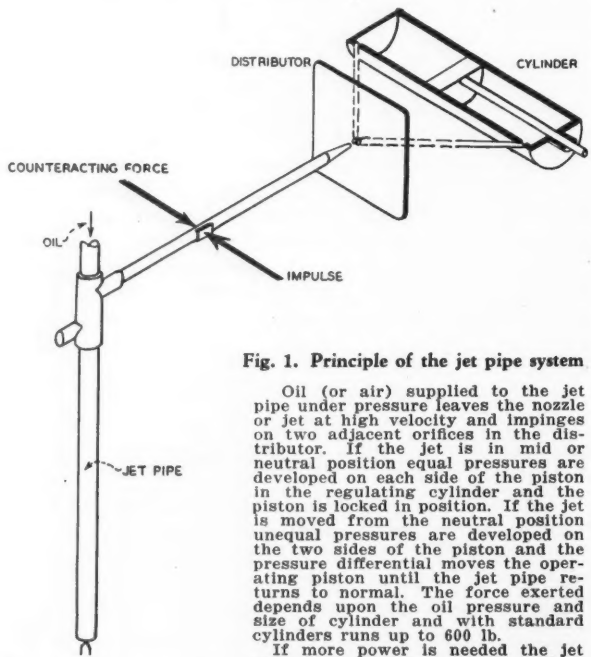


Fig. 1. Principle of the jet pipe system

Oil (or air) supplied to the jet pipe under pressure leaves the nozzle or jet at high velocity and impinges on two adjacent orifices in the distributor. If the jet is in mid or neutral position equal pressures are developed on each side of the piston in the regulating cylinder and the piston is locked in position. If the jet is moved from the neutral position unequal pressures are developed on the two sides of the piston and the pressure differential moves the operating piston until the jet pipe returns to normal. The force exerted depends upon the oil pressure and size of cylinder and with standard cylinders runs up to 600 lb.

If more power is needed the jet operates a four way valve or relay. The impulse and counteracting force is applied in a variety of ways as shown in succeeding drawings. In cases where there is an inherent time lag in the system a stabilizer, shown by Fig. 2, is added to prevent hunting.

In cases where there is an inherent time lag in the system being regulated a stabilizer as shown by Fig. 2 is added to prevent over shooting and hunting. The speed and pull of the piston depends upon the diameter and stroke of the piston, diameter of the oil jet and the pressure of the oil. In the application shown here this arrangement gives sufficient power (up to 600 lb.) to operate turbine throttle valves and motor rheostats directly. In cases where more power is needed the jet is made to operate a four way valve similar to the pilot valve on an ordinary damper regulator. Thus the power available is limited only by the capacity of the oil pump.

A diagrammatic arrangement of the system as applied to one of a number of boilers is shown by Fig. 3. The master regulator, which consists of a weight loaded sylphon bellows connected to the header pressure, is pivoted so as to move a jet pipe. Instead of the usual medium, oil, the jet pipe is supplied with air at about 10 in. of water, by a small fan, so as to match the differential pressures being measured by the other regulators. As the master regulator has only to send out an impulse proportional to the steam load but one orifice is required, the master impulse varying directly as the displacement of the jet from normal and with a maximum value for maximum steam load.

The control operates the speed of the forced draft fan in order to maintain a constant ratio between boiler load and air flow, it maintains a constant ratio between fuel and air by regulating the speed of each stoker in proportion to the air supply, and finally, it maintains a constant over-fire pressure by regulating the speed of the induced draft fan.

Steam pressure in the main header acts upon the sylphon of the master regulator (M) and is balanced by a weight. The difference between the weight on

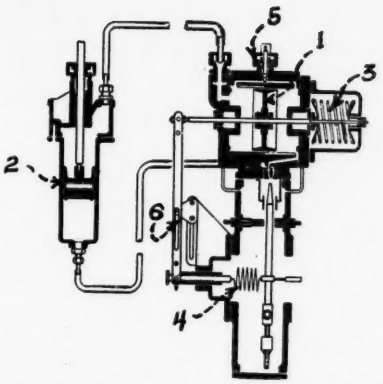


Fig. 2. The hydraulic stabilizer as used with the furnace draft regulator shown in Fig. 3

Compensation provided by the stabilizer prevents overtravel or hunting where there is an inherent time lag in the system being regulated. With the furnace pressure regulator this time lag is caused by the inertia of the turbine and induced draft fan.

The stabilizer acts as follows: If the jet pipe is moved to the left due to an increase in furnace pressure, stabilizer piston 1 moves to the left and piston 2 moves downward to open the turbine throttle valve and increase the fan speed. As piston 1 moves to the left it compresses springs 3 and 4. Under the action of spring 4 the jet is returned to neutral position preventing further movement of piston 2. Under the action of spring 3, piston 1 is gradually returned to midposition, the rate of return being regulated by valve 5 in the bypass line shown at the top of the cylinder. Different time lags may be taken care of by varying fulcrum 6 and the bypass setting. If the rate of return of piston 1 agrees with the rate of furnace pressure change due to the changed position of piston 2, the jet pipe remains stationary under the action of the equal and opposed forces. If the two rates do not agree there is a further readjustment until a balance is reached.

one side of the weigh beam and the steam pressure on the other side acts to move the jet pipe. Displacement of the jet changes the impulse loading pressure and this pressure, effective on the outside of the left hand diaphragm of the master regulator balances the steam impulse on the right hand side. With each change of the steam impulse the jet pipe position changes until the air impulse again balances the steam impulse. The air impulse created by the master is therefore a direct function of the steam pressure variation from normal.

Master air impulse is transmitted to the right hand diaphragm of each load regulator A, while the left hand diaphragm of the load regulator is actuated by the air flow to the boiler, the air flow being measured by means of an orifice plate in the air supply line to the boiler. Each load regulator regulates the steam supply to the forced draft turbine, thus maintaining a constant proportion between steam load and combustion air supply.

Air flow to the boiler, measured as described above, also actuates the left hand diaphragm of the combustion regulator B, the right side of which is actuated by an impulse proportional to the stoker speed. This impulse is created by a measuring fan (Fig. 5) driven by the stoker drive and creating a suction impulse proportional to the square of the stoker speed. Regulator B of each boiler thus maintains a constant ratio between air supply and stoker speed or between fuel and combustion air.

The furnace pressure regulator C of each boiler operates independently from the other control equipment. It regulates the speed of the induced draft fan in such a way that the over-fire pressure remains constant. As shown on the drawing, the furnace pressure regulator is equipped with a hydraulic stabilizer (Fig. 2) to avoid over-regulation due to the time lag which exists between any movement of the steam throttle valve in the inlet to the fan turbine and the result of this movement measured as pressure change in the boiler furnace.

Flexibility in the operation of the plant so as to allow either manual or automatic adjustment is provided by valves which, for simplicity, are eliminated from Fig. 3 but which are shown separately by Fig. 4.

Three way valve 2 located on the boiler panel provides means for disconnecting regulator A from the master impulse line so as to allow base load or manual operation of that particular boiler. The boiler rating can be varied manually by means of a handwheel which by means of spring 3 loads the diaphragm and determines the positions of the jet. The balance of the equipment operates the same as under automatic control so as to maintain the desired air-fuel ratio.

Individual adjustment of regulators B and C may be made by the respective ratio sliders but manual control may also be obtained by installing a five way valve at 4 to disconnect these two lines from the regulator and connect them direct to the oil supply lines. An inspection of the ratio slider, for instance, on Fig. 4, will show that moving the slider changes the pivot points of the two opposing forces. In the mid position as shown the ratio is one to one. If the slider is raised the mechanical advantage of the left hand force increases.

The five way valves have four positions, one for automatic operation and three for manual operation. With manual control the regulating piston may be moved in either direction or held locked in any position. With manual operation the fuel regulator follows

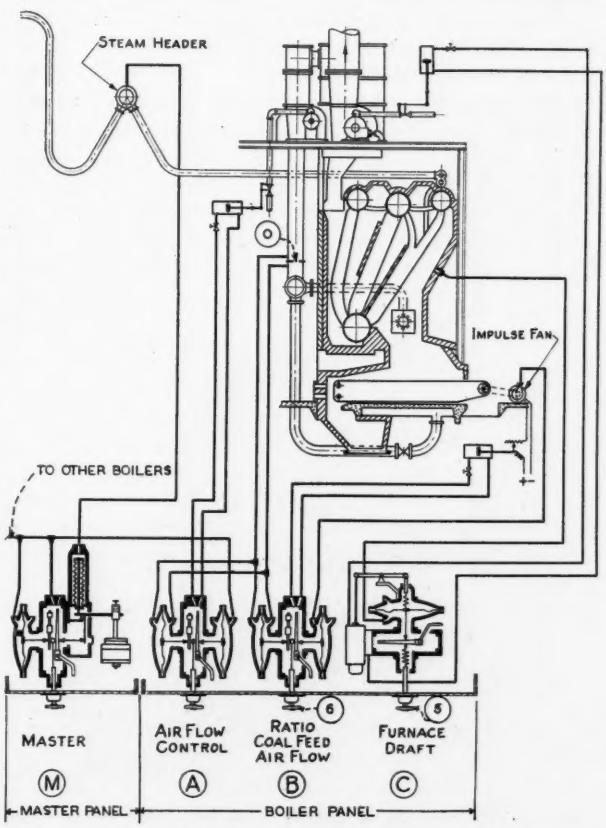


Fig. 3. Diagrammatic arrangement of the Askania system applied to a chain grate stoker installation. For simplicity provisions for changing from automatic to manual control are shown separately by Fig. 4.

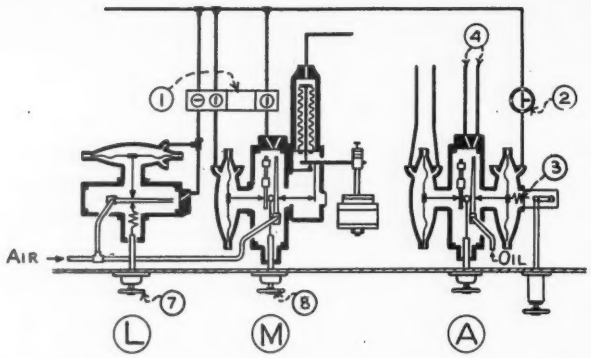


Fig. 4. Details of the provisions for changing from automatic to manual control. For simplicity, these details were left off Fig. 3

By means of the false loading devices the whole plant may be operated as a unit under manual control or any boiler may be operated under base load while the rest of the plant continues under automatic control.

Master loading impulses are sent to the individual regulators either from the master, M, or from the manual loading regulator L. As shown in the drawing the master M is in control. If the switch-over valves, 1, are turned 90 degrees the master is disconnected and the impulse loading pressure is then determined by the manual adjustment of the jet of transformer L.

Individual boiler load regulators may also be set manually regardless of the master loading impulse by turning the three way valve 2 of regulator A, clockwise, so as to cut off the master impulse and vent the diaphragm to atmosphere. The boiler rating is then set manually by means of a handwheel in the front of the board which loads the spring 3 and thus determines the position of the jet. Provision for operating any of the dampers manually may also be provided by installing five way valves in the oil pressure lines from the individual regulators for instance as indicated above at 4 on regulator A. Operation of these valves is explained further in the text.

the air supply as with automatic operation. The three crossconnected valves 1 of Fig. 4 allow manual or base load operation of the entire plant by isolating the master M and creating a false master loading by manual loading regulator L.

Typical master and boiler panels are shown in the headpiece. The multipoint gages shown in the headpiece indicate the windbox pressure, furnace draft, boiler outlet draft and air flow differential, so that the operator has full knowledge of operating conditions at all times whether under manual or automatic control. At the lower left hand corner of the multipoint gage is the three-way valve. To the right of this switch is the oil pressure gage and start and stop buttons for the oil pump. Underneath these and reading from right to left are: furnace pressure regulator, adjustment 5 on regulator C of Fig. 3, by which the furnace pressure may be changed as desired; combustion or fuel air ratio, adjustment 6 on regulator B of Fig. 3, by which the fuel supply for a given master impulse may be changed; load control for manual operation, adjustment 7 on regulator L of Fig. 4; load control for automatic operation, adjustment 8 on regulator M of Fig. 4.

Fig. 6 shows the general arrangement of control for an oil fired boiler where the fuel is metered by an orifice operating in conjunction with a Brown static converter. This instrument converts the differential pressure across the orifice due to the oil flow into a force directly proportional to the impulse which varies as the square of the oil flow. This force is balanced by the differential pressure across the boiler or air orifice which varies as the square of the air flow. The fuel flow is therefore directly proportional to the air flow, both are proportional to the boiler load and the exact fuel-air ratio, which is adjustable, is determined by the setting of the ratio slider.

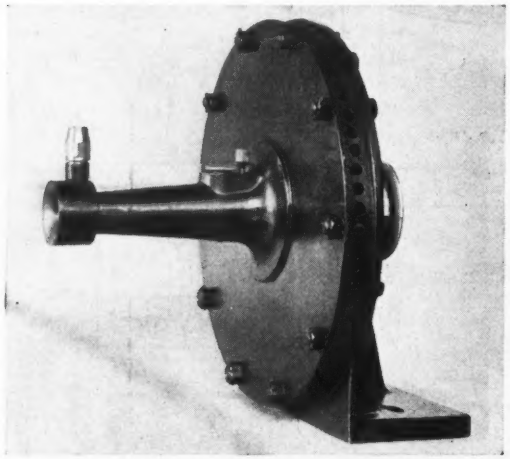


Fig. 5. This fan, driven directly from the stoker motor shaft delivers a volume of air directly proportional to (the speed and therefore to) the fuel feed. The air flow is measured by the suction in a Venturi tube built into the fan inlet as shown at the left hand side

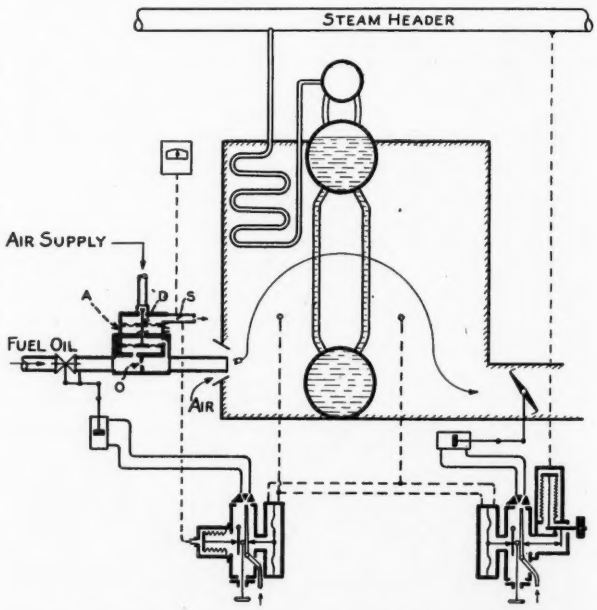


Fig. 6. Application of the Askania control to an oil fuel boiler

In this case changes in header pressure are balanced against the draft loss through the boiler on regulator 1, to open or close the outlet damper so as to give the proper air supply. The draft loss is effective on the right hand side of regulator 2 and moves the jet pipe to control the flow of fuel oil, until balanced by the loading pressure from the Brown static converter A.

Operation of the control is as follows: For an increase in steam load the header pressure drops, moving the jet pipe on regulator 1 to the left so as to open the outlet damper. As the damper opens, the draft loss through the boiler increases and tends to move the jet pipe back to neutral position. At the same time this draft loss, effective on the right hand side of regulator 2, moves that jet to the left and increases the flow of fuel oil. As the flow increases, the drop across orifice O of static converter A, increases and lifts the diaphragm and valve D, admitting more air into space S and increasing the pressure which, effective on the right hand side of regulator 2, returns the jet pipe to neutral position.

In the case of gas firing regulator 1 is used as shown above but regulator 2 is replaced with a double diaphragm type as shown by regulator A of Fig. 3. The draft loss through the boiler is balanced directly by the pressure differential across an orifice in the gas line.

New Insurance Rates for Diesels

NEW COVERAGE and rates for insurance on Diesel engines, in many cases representing substantial reductions from rates previously in effect, have been announced by the Boiler and Machinery Department of the National Bureau of Casualty and Surety Underwriters, effective May 1, 1936. Promulgation of the new rules follows closely the adoption by the Diesel Engine Manufacturers' Association of changes in their "Standard Practices," and has resulted from a series of conferences between committees of the two organizations.

Some years ago when the Diesel engine was relatively new and the characteristics of its design were not so well understood, there were some misapplications involving inadequate power capacities, improper cooling systems and poor maintenance. These cases gained wide attention, primarily because of the new type of prime mover, and some engineers formed the opinion that Diesel equipment was inherently prone to a higher frequency of enforced shutdowns than was steam equipment.

Actually there is no reason why Diesel engines should not show as favorable loss experience as steam apparatus, in cases where the Diesel engine is properly selected for the character of service and the load requirements, where it is correctly installed with an adequate and reliable cooling system, as well as necessary auxiliaries, and where the system of maintenance is kept up to a proper standard.

In the new Standard Practices, (see book review Power Plant Engineering p. 80 January 1936) the manufacturers lay great stress on the advisability of installing closed cooling systems, it having been found that many troubles—namely, cracked cylinder heads, cracked pistons, stuck pistons and other difficulties of a like nature—have been due to improper cooling conditions. The use of the open cooling system, in which raw water circulates through the engine and goes directly over the cooling tower or through the spray pond, is usually the cause of such accidents. Experience has shown that even though the make-up water in an open system goes through a softening process, this practice does not eliminate all breakdowns.

With the greatly widening field of usefulness of the Diesel engine, it became apparent that all users should become better acquainted with approved methods of installation and operation. With this end in view, the insurance companies, acting through the National Bureau of Casualty and Surety Underwriters, entered into discussions with the Diesel Engine Manufacturers' Association from which has resulted the constructive coöperation referred to above.

The plan of rating inaugurated by the insurance companies contemplates rate differentials for the following four classes of Diesel engines:

CLASS 1. Engines manufactured in 1925 or later and provided with a Closed Cooling System.

CLASS 2. Engines manufactured prior to 1925 and provided with a Closed Cooling System.

CLASS 3. Engines manufactured in 1925 or later and provided with an Open Cooling System.

CLASS 4. Engines manufactured prior to 1925 and provided with an Open Cooling System.

Under the new plan, the rates for Class 1 engines are, for the most part, considerably lower than under the old plan, although the changed basis of rating, from cylinder number and size to horsepower capacity, prevents definite comparison except in individual cases. For the other three classes, rates may be either higher or lower than previously, but the general trend is to produce lower rates for Class 2, higher rates for Class 4 and very little change for Class 3.

The engineering and inspection service which customarily is furnished by the insurance companies is available in connection with internal combustion engines. This service is perhaps better known in the broader field covering the inspection of boilers, steam engines, turbines and electrical machinery; but has been just as effective in the case of internal combustion engines in correcting improper conditions and detecting incipient causes of trouble. The establishment of more uniform standard practices for the installation and operation of such engines and the concerted coöperation of the manufacturers will, of course, broaden and make more effective the service afforded by the insurance engineers.

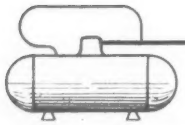
Power Production Efficiency in Great Britain

SOME INTERESTING DETAILS of power production efficiency in Great Britain are given in the recently-issued report for 1935 of the British Electricity Commissioners. The total kw-hr. generated at the 458 electric power generation stations covered by the report was 18,933 million, an increase of 12.42 per cent over 1934, for a fuel consumption of 12.5 million tons, an increase of 8.9 per cent. Of the total 95.33 per cent was produced by steam stations with an average coal consumption per kw-hr. generated of 1.54 lb., an improvement of 0.04 lb.

The lowest fuel consumption per kw-hr. generated, 0.96 lb., as well as the highest thermal efficiency, 28.59 per cent, was returned by the London Power Co. for its Battersea station, this being the first British power station to generate power at less than one pound of coal per kw-hr. Barking B of the County of London Co. came second under both headings with 1.09 lb. and 28.07 per cent, followed by Dunston B of the N.E.S. Co. with 27.25, Clarence Dock (Liverpool Corporation) 26.21, and Ironbridge (W. Midlands J.E.A.) 25.59 per cent. Twenty other stations achieved thermal efficiencies of more than 20 per cent. Eleven oil-engine stations returned efficiencies equal to or better than Battersea at 28.59 per cent. The station of the Machynlleth Electric Supply Co., secured first place for thermal efficiency with 31.78 and for fuel with 0.569 lb. per kw-hr. As to other kinds of prime-mover, Leek has the largest gas-producer station, which produced over three million kw-hr. for 1.83 lb. of coal per kw-hr., as against the average for this type of station of 2.14 lb.

The Steam Accumulator is a device which can often be used to advantage in cases where a highly fluctuating load exists. This article presents a specific case. The quantities and values are precisely those submitted to the owners of the factory

By PELL W. FOSTER, Jr.
Foster Wheeler Corp.



Increasing Steam Capacity *by means of* Accumulators

IN ORDER TO meet the increasing steam demands resulting from improved business conditions many industrial organizations find it necessary to increase the capacity of their boiler plants.

The most obvious way of doing this is, of course, to install new or additional boiler capacity and in many instances this may be the most desirable solution to the problem. Other methods are available, however, and in any particular case, it is advisable to make a thorough analysis of all possible alternatives so that in the end equipment will be selected which will give the best economic balance between first cost and increased capacity.

Aside from the most obvious method of increasing the capacity of the boiler plant, i.e., of adding boilers, the use of steam accumulators offers attractive possibilities in many instances. Approximately 600 installations of steam storage systems have demonstrated that the accumulator is practical and offers an economical means of increasing the operating efficiency of the boiler plant, providing additional steam capacity without the expense of adding new boilers.

The principle of the Ruths steam storage system is well known and this article is confined to an actual investigation recently made for a prominent American concern having many factories and operating many boiler plants. Comparison will be made of the relative first cost and boiler plant efficiency between a Ruths Accumulator and a new boiler.

Figure 1 shows the steam demand for the plant investigated. The demand fluctuates quite rapidly from 50,000 lb. per hr. to 270,000 lb. per hr. The erratic operation of boilers to meet these conditions means loss in fuel efficiency and higher maintenance costs, due to the rapidly changing furnace conditions.

If an accumulator should be installed in this plant, the peaks and off peaks in steam demand would be absorbed by the accumulator, and the boilers would generate steam at a steady rate which would promote highest efficiency and reduce the maintenance and wear to a minimum. The boilers would be called upon to deliver only the average steam requirement and the boiler capacity in operation could be reduced to the extent of the maximum peak demand above the average. Also, the steam demand could be increased within this amount without installing additional boiler capacity.

Theoretically, an accumulator should be designed with sufficient capacity to absorb all variations from an average demand over 24 hours operation. This would require quite a large accumulator installation, in many cases, and the investigation showed to what a great extent a comparatively small accumulator capacity can reduce operating boiler capacity and improve operating efficiency.

Figure 2 indicates, diagrammatically, the arrangement of the investigated plant. As the volume of steam demand in the 15 lb. steam line was not sufficient to balance the fluctuation in the boiler load, the pressure range for the accumulator had to be limited between 180 lb. and 120 lb. per sq. in. This narrow pressure range is, of course, rather unfavorable for the accumulator, as the relatively small pressure drop reduces the output of steam per cubic foot and necessitates a large total volume.

The study showed that the steam capacity of the existing boilers was:

BOILER CAPACITY

	Lb. per Hr.
1800 hp. pulverized coal fired boiler at efficient rating—250 per cent	145,000
1300 hp. stoker fired boiler at efficient rating—200 per cent	83,000
Total of	228,000
Steam demand—maximum	270,000
Expected increase—future demand	47,000
Total future load	317,000

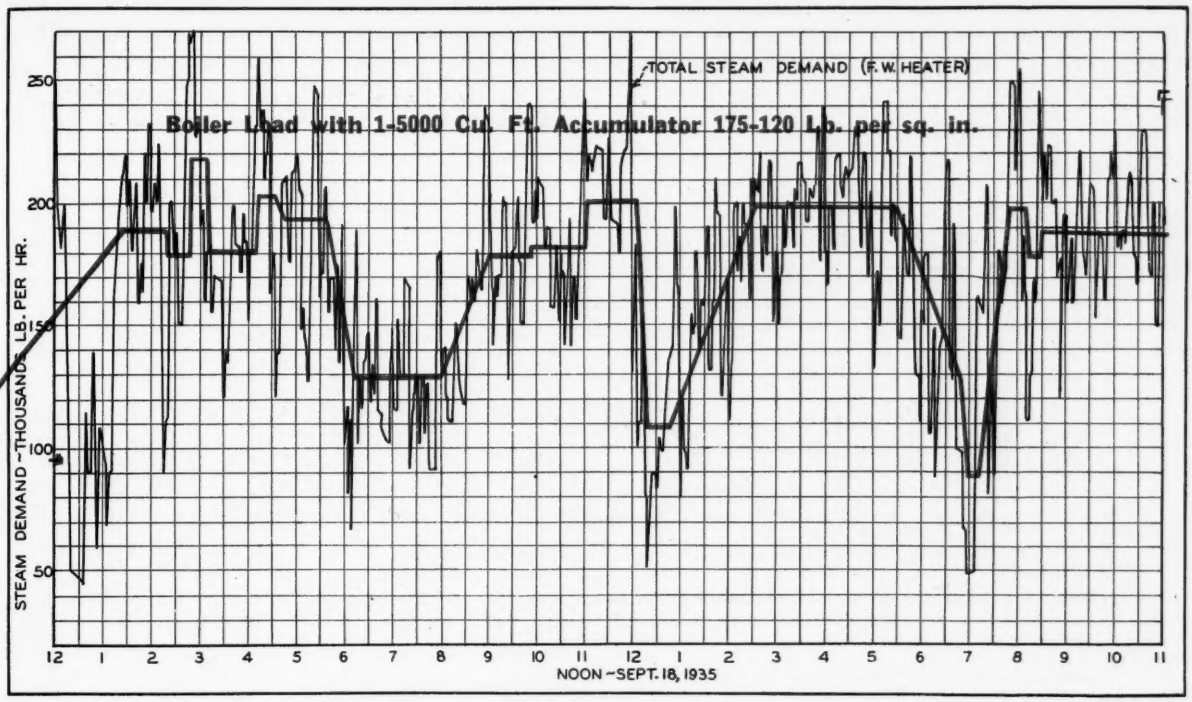

TOTAL STEAM DEMAND (F.W. HEATER)
Boiler Load with 1-5000 Cu. Ft. Accumulator 175-120 Lb. per sq. in.
STEAM DEMAND-THOUSANDS LB. PER HR.
250
200
150
100
50
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11
NOON-SEPT. 18, 1935

Fig. 1. Chart showing wide and rapidly fluctuating steam demands and effect on boiler load of an accumulator

In order to provide for the increased demand, two propositions were estimated as follows:

(a) Two 600 hp. pulverized coal boilers for 200 lb. per sq. in. gage pressure and for economic operation at 200 per cent of rating = 78,000 lb. per hr. of steam.

(b) One 600 hp. pulverized coal fired boiler for 200 lb. per sq. in. and 200 per cent rating and one 5000 cu. ft. accumulator having a capacity of 8000 lb. per hr. of steam.

Capacity of Proposition (a)

Old boilers	228,000 lb. per hr.
Two new boilers	78,000 lb. per hr.
Boiler capacity at efficient rating =	306,000 lb. per hr.

Capacity for Proposition (b)

Since the peaks as shown in Fig. 1 have a duration of from 5 min. to a maximum of 20 min., and the peaks are of triangular shape, the accumulator can absorb peaks of the following magnitudes:

5 minutes duration at base of peak:

$$8000 \times \frac{60}{5} \times 2 = 192{,}000 \text{ lb. per hr.}$$

20 minutes duration at base of peak:

$$8000 \times \frac{60}{20} \times 2 = 48{,}000 \text{ lb. per hr.}$$

Duration of peaks	20 min.	15 min.	10 min.	5 min.
Old boiler	228,000	228,000	228,000	228,000
One new boiler	39,000	39,000	39,000	39,000
Accumulator	48,000	64,000	96,000	192,000
Efficient peak capacity	315,000	331,000	363,000	459,000

From the above figures it is evident that the accumulator and one new boiler will provide for more peak capacity than two new boilers when operated efficiently.

Installation Cost

(a) Two 600 hp. boilers. Total	$121,000
(b) One 600 hp. boiler and one 5000 cu. ft. accumulator	96,400
Saving in first cost in favor of accumulator or 20 per cent	$ 24,600

Yearly Operating Cost

	Prop. (a)	Prop. (b) with Acc.
13 per cent fixed charges old equipment	$65,000	$65,000
13 per cent fixed charges new equipment	15,700	12,500
Coal cost $5.66 per ton	87,000	82,800
Labor—50c per hr.—average	14,000	12,000
Maintenance	920	880
Purchased power 1.65c per kw-hr.	11,000	11,000
Total operating cost	$193,620	$184,180

This shows a saving in yearly operating cost of $9,440 in favor of the accumulator installation.

In addition to the above savings in installation cost, and yearly operating cost, a number of other benefits, not easily expressed in dollars and cents, will be obtained due to the accumulator installation:

1. Constant steam pressure with increased efficiency of prime movers, and more uniform operation of processing equipment, usually results in reduced steam demand and improved quality of products.

2. If the plant in the future should install high pressure boilers and turbo generators to generate its own power, an accumulator would be almost indispensable as power cannot be generated satisfactorily with a steam demand fluctuating as for this plant.

3. The accumulator installation as shown in Fig. 2 would operate equally satisfactorily with or without power generation, and would continue in service whereas low pressure boilers installed at present would

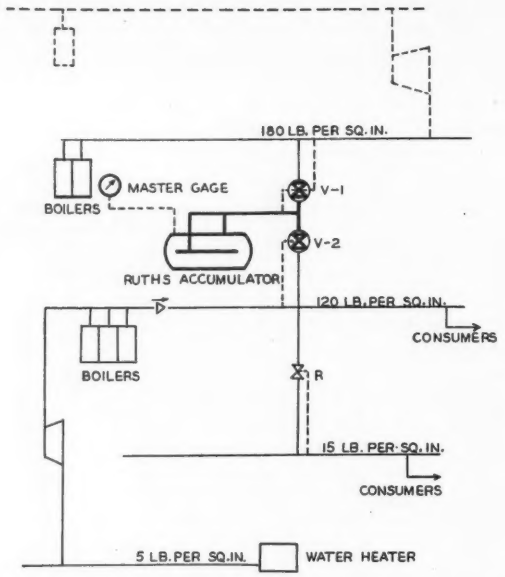


Fig. 2. Diagram showing arrangement of equipment and steam pressures

be obsolete, if high pressure steam power equipment was later decided upon.

The plant covered by this investigation is by no means outstanding in regard to savings obtainable by the accumulator. As pointed out, the narrow pressure range available increased the price for the accumulator per unit storage capacity, and if sufficient demand had been available at the 15 lb. per sq. in pressure, the savings in installation cost would have been considerably increased. Such studies are enlightening and may be of considerable interest to operators facing the problem of increasing steam capacity.

Attaching Sockets To Wire Ropes

WHEN A SOCKET has to be attached to a wire rope, measure off at the end of the rope a length equal to that of the basket of the socket. Secure at this point with not less than three seizings, open out the strands, cut out the hemp center if used; if a wire strand is used as a center this should be left. The strands should be separated and straightened. Clean each one with kerosene to as near the first seizing as possible, then wipe dry. Make up a solution of half muriatic acid and half water.

The strands should be dipped in this for three-quarters of the distance to the first seizing; leave them in this for a few minutes, then wipe them dry. Close the strands into rope form and put them in the socket; cut the seizing wires and make sure that the socket is in line with the axis of the rope, otherwise the strands will be unevenly loaded. Fire clay should be placed around the socket so that it stands vertical. Some high grade molten zinc should then be poured in at a temperature of 830 deg. F. This temperature should not be exceeded. Babbitt or white metal should not be used instead of zinc because of their lack of strength. The zinc should be allowed to cool as slowly as possible. When quite cold the socket is ready for service.

Boiler Circulation Troubles

TROUBLE DUE to leaky tubes and corrosion in certain sections of large boilers has been reported by a number of utility companies in publication No. C4 of the Edison Electric Institute. One of these cases was on the top rows of a cross drum boiler at Hudson Ave. Station. Leakage occurred at the rolled joints where the tube joined the riser headers and was usually found to occur after the boilers had been in operation at or above the maximum steam flow of 350,000 lb. per hr.

Even after the installation of 3¼ in. diameter ferrules in the top of the 4 in. OD connecting nipples joining the upper and lower tube sections, temperatures in the upper ends of the tubes were found to be as high as 800 deg. F. When the next boilers were installed, three instead of two horizontal rows of top circulators were provided. Less leakage has been experienced on these boilers and although it is not

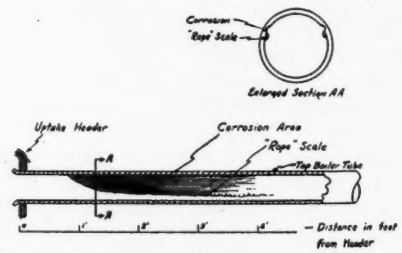


Fig. 1. Showing corrosion areas in boiler tubes

thought that the additional row of circulators is entirely responsible for the improvement, it is felt that they have contributed to the tightness of the joints.

Another case is reported by the Byllesby Engineering & Management Corp. which states that in 1932 a top boiler tube from a cross drum, straight tube, three pass boiler with a capacity of 250,000 lb. per hr. at 450 lb. per sq. in., ruptured. Failure occurred at an angle of 35 deg. from the top of the tube and an investigation indicated that corrosion was taking place over a length of from 3 to 6 ft. due to the tube not being full of water.

Early operation of this station formed a rope scale along the apparent water line as shown in Fig. 1. This was reduced and softened by a change in water treatment but a loss of metal resulted, the maximum attack being near the water line where the scale might have previously acted as a protective covering. Investigation was made to determine the local temperatures. The length and temperature of the dry areas was found to be less near the side walls, both increasing with load. The tubes lower in the bank showed normal temperatures at moderate ratings but increased at higher rating, indicating that they, too, became dry. This effect was noticeable down to the sixth row from

the top when operated at maximum rated capacity.

Various forms of baffles in the headers and restrictions in the connecting nipples give little reduction in temperature. Test with solid plugs and a number of sizes and shapes of pipe cores were made and fairly satisfactory temperatures were obtained in the top tubes with solid plugs installed in the lower ends. These, however, were not satisfactory in the lower tubes and in addition did not eliminate the characteristic dark areas at the top of the tubes and formed dead pockets where sediment collected.

Most satisfactory temperatures in the top tubes were obtained with straight pipe cores having plugged ends each with an external area equal to approximately 75 per cent of the internal area of one tube. Each core extended down the tube approximately 80 per cent of its length.

On the installation where the above tube failure occurred consideration was given to the installation of additional circulators to and from the drum but the benefits to be derived did not appear to warrant the expense and complication, so, cores were installed in those tubes which had previously shown high metal temperatures. Operation since 1933 has been entirely satisfactory.

No loss of metal has occurred and no scale has been deposited in the cored tubes but apparently the cores have not materially altered the quantity or changed the direction of water flow. It is still reverse, or down the tube, and the effectiveness of the core in reducing metal temperature appears to lie in its local

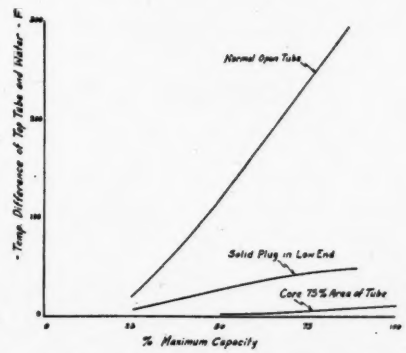


Fig. 2. Tube temperatures with different arrangements

action in causing a more frequent wetting of the tube surface. While the exact mechanism of the corrosive action was not determined, it is known that the action of any corrosive agent which may be present in the water will be accelerated by increased metal temperature.

Similar surveys were made in plants containing other conventional makes of straight tube, cross-drum boilers and all showed the same tendency toward high metal temperatures in the upper tubes when operated at high rates of heat absorption. Loss of metal, however, has occurred only in units which have operated for long periods at high sustained capacities.

Cores were also used in Hell Gate Station where occasional failures of boiler tubes in some 12 high, sectional header, boilers led to studies to determine the cause and means of remedying the difficulty. Failures are not very frequent nor serious when they occur, a small transverse crack forming on the top of upper tubes in the first pass within a few feet of the upper header. Internally, the tubes which fail show characteristic water lines with internal corrosion at the point of cracking. The corrosion appears to produce a notched bar effect which, in turn, results in stress concentration and a fatigue crack.

Thermocouples were secured to tubes in the upper bank of the first, second and third passes and metal temperature observations for various ratings were taken. It is felt that the heating to excessive temperatures, together with alternate cooling, was responsible for the failures.

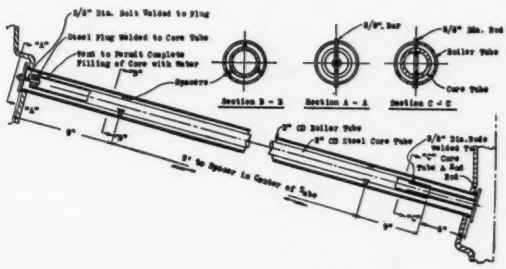


Fig. 3. Arrangement of cores used in tubes

In an effort to lower tube metal temperatures, cores as illustrated in Fig. 3 were installed in a few tubes and temperature records were again taken. As the size of the cores is increased the tube temperature condition is improved and, with a full length core having a cross-section area of 75 per cent of the tube, the tube temperatures do not exceed 500 deg. F. A great many observations have been recorded and the figures reproduced here were selected at random to indicate the temperature trend.

Various size orifices were installed in the lower ends of some of the boiler tubes in the upper banks, it being found necessary to reduce the orifice size to a very small opening before the tube metal temperatures could be maintained at a reasonable value. One tube was completely plugged at the lower end and operated several months in this condition with very good results, the temperature of the tube metal being but slightly above saturation temperature. When the plug was removed after a few months operation the lower end of the tube was found to contain mud and solid matter for a distance of several feet.

Samples of water withdrawn from upper tubes indicated a pH value in the neighborhood of 5, whereas the boiler water proper had a pH value of 10 or more. Apparently the water sample collected was in reality condensed steam from the tube, as it checked approximately with the condensed steam pH value.

The majority of tube failures have occurred in boilers in which the superheater is located above the upper bank of tubes and consequently, the gas temperature adjacent to the upper boiler tubes is correspondingly higher than it is in the boilers having interdeck superheaters. Studies of the many different possibilities which suggest themselves are being continued at this station with a view of determining the most acceptable method of improving the circulation.

Present Day Diesel Fuels *and* Fuel Specifications

Introduction of the high speed engine and new refining methods complicate the Diesel fuel problem.

By T. M. Robie[1]

DURING THE PAST FEW YEARS there has been a rapid development in smaller cylinder bores and increased speeds of Diesel engines which have had a marked effect on the fuel oil requirements. The first engines were of the slow speed, heavy duty type, with comparatively large cylinders. By this is meant speeds of 90 to 250 r.p.m. and cylinder bores in excess of 12 in. diameter. Many of these engines employed high pressure air for the injection of the fuel. The injection nozzle orifices were of the single hole type with diameters of 0.050 in. or more. It was not uncommon to have two fuel oil reservoirs, permitting the use of a light distillate for starting.

With these early engines, many claims were made as to the fuel which could be successfully burned. These early claims were not so ridiculous as they might appear today and many of those engines really would operate on "any fuel which would flow through the pipes." They might encounter carbon difficulties and inability to carry full load, or failure to meet the fuel consumption guarantees, but they would run for a while at least. It is generally recognized that the larger engines of today are not so sensitive to fuels as are the smaller, higher speed types. There are many large installations in which the saving in cost with a low grade fuel will justify the use of centrifuges and preheaters for the fuel supply. Obviously the specifications for an installation of this kind will differ from those for an installation where these accessories would be uneconomical. In this paper we will consider only the latter type of plant.

In reading over the various specifications which have been offered, reference was made to Bulletin 156 of the Department of the Interior, entitled "The Diesel Engine, Its Fuels and Uses" by Herbert Haas, and published in 1918. The following excerpt from the above will be of interest.

Tests for Suitability

To determine the suitability of petroleum products as fuels for Diesel engines, they should be classified by tests as to the following properties, stated in the order of their importance:

1. Boiling Point Range
2. Ash Content
3. Mechanical Impurities
4. Heating Value
5. Water Content
6. Coke Content
7. Asphalt Content
8. Paraffin Content
9. Sulphur Content
10. Acidity
11. Elementary Composition
12. Viscosity
13. Flash Point
14. Burning Point
15. Specific Gravity

The above specifications have stood the test of time well, but we believe the author of them would now agree that there should be a change in the line-up, and that by limiting certain of the items, others could be omitted. It is difficult to assign any order of importance to some of these items while others should be in the first rank. We agree that the boiling point range, or distillation test is one of the most important. It is valuable in showing whether the oil is an overhead product or has been made up with some of the heavy ends of the refining process or with the residuum left in the still after the lighter distillates have been removed. These heavy products burn poorly or not at all in a Diesel engine and their presence should therefore be controlled. Generally speaking, a suitable Diesel fuel should distill 95 per cent or more over at 700 deg. F.

We are inclined to place the Conradson Carbon Test next in line of importance to the distillation test. Our experience indicates that an oil with a high Conradson Carbon percentage, say above 3 per cent, will always give unsatisfactory operation as evidenced by high fuel consumption, somewhat smoky exhaust and a tendency to form carbon deposits. Our specification would therefore limit the Conradson Carbon to 2.0 per cent.

For the next most important item, viscosity would probably be chosen. This is a measure of the rate at which oil will flow and is expressed as the number of seconds required for a given quantity of the fuel to pass through a standard orifice at a constant temperature. This apparatus is called a Saybolt Viscosimeter. With the extremely small clearances maintained in the fuel injection pumps, there is a need for a certain amount of lubricating value in the fuel so that one of too low a viscosity is not desirable.

On the other hand, with too high a viscosity, the oil will not flow freely through the pipes and will not atomize properly. Aside from the lubricating value, viscosity undoubtedly has an effect on the combustion characteristics. The size of the fuel droplets and their

[1]Fairbanks, Morse & Co. This is an abstract of a paper presented at the Sixth Midwest Power Engineering Conference in Chicago.

penetration into the combustion chamber are functions of the viscosity and we predict that this property will gain in importance as our studies progress. A good workable viscosity range would be from 35 to 75 sec. Saybolt Universal at 100 deg. F.

It is interesting to note that the item covering ash content has disappeared from current refiners specifications, although it remains in those of the engine builders. In a refined oil the ash content would consist almost entirely of dirt and non-combustible impurities picked up from storage tanks, drums and plant piping. Obviously, material of this kind would be of an abrasive nature causing wear in the fuel injection system and on the cylinder walls. To protect the customer from careless handling of the fuel by the vendor, we would recommend that this item be included in the specifications, with a limit of 0.05 per cent maximum.

Bottom sediment and water is determined by means of a laboratory centrifuge. A limiting value is important because the sediment may well be non-combustible matter in a class with the ash already mentioned, while the presence of water will cause irregular operation or even complete stoppage of the engine. As in the case of ash forming materials, the source of water in any appreciable quantity is usually in the handling of the fuel after it leaves the refinery. We would recommend a B.S.&W. limit of not more than 1 per cent.

The test for sulphur is somewhat complicated and ordinarily consists of burning a sample of the fuel in a bomb and recovering and weighing the sulphur in the residue. From a combustion standpoint there is no objection to any ordinary amounts of sulphur. Large percentages of sulphur, under very light load conditions, and with frequent starting and stopping, might conceivably result in a pitting of the exhaust valves. It has also been known to corrode the exhaust pipes due to the formation of sulphuric acid by combining with the water vapor formed by combustion. For the above reasons, the sulphur should be limited to 1.5 per cent.

The remaining properties which are usually considered have no particular bearing on the combustible nature of the fuel, but have certain informative values to the user for other reasons. These items are as follows: Pour Test, Flash and Fire Points, Specific Gravity, Color, and B.t.u. per pound.

The above are the specifications which have been considered ever since the earliest Diesel engine and up to the advent of the present day high speed, automotive type. With these new engines, the need for additional specifications became quickly apparent, as with many of the available fuels, the operation of the engines was much noisier and rougher than was the case of those of larger size. It took but little time to discover that all fuels did not react the same, even though the specifications outlined above were identical. The problem was thus to determine what additional specifications would be necessary to evaluate the ignition or combustible properties.

Let us now review the reasons why present day engines require a somewhat different fuel than their predecessors. The principal change has been in the matter of rotative speed and reduced cylinder bores. One of the latest automotive Diesels to be announced has a bore of only 3½ in. and a top speed of 2600 r.p.m., while in the larger engine field we find 14½ by 18 engines being offered to run at 400 r.p.m., or twice the speeds common in the earlier engines of the same size. Air injection and large diameter orifices have been replaced with solid injection and nozzle tips with holes as small as 0.005 in. in diameter and in which the valve needle requires 1500 lb. per sq. in. or more to open.

In 1930, H. R. Ricardo advanced the idea that there are three rather definite stages in the combustion of fuel in a compression ignition engine. The first or delay period is the time required after the start of injection to bring the temperature of the entering charge to the point of ignition. The second stage is that of the rapid combustion of the fuel which has already been injected with corresponding increase in pressure. The third and last stage is the burning of the remainder of the fuel as it is being injected. Various investigators have disagreed regarding the extent and minor characteristics of the above three stages, but it is generally accepted that, with certain modifications, they do exist.

Ordinarily, the longer the delay period, the greater will be the pressure rise in the second stage. This may be easily understood when we consider that the longer the delay, the more fuel will be present in the combustion space. The rapid rise of pressure in stage two is what causes roughness of the engine.

To give you an idea of the effect of higher speeds on ignition and combustion, a brief example will be given. The assumptions, while not absolutely correct, are made for the purpose of simplicity. Let us assume that the heat conditions at the beginning of injection are the same on an engine running at 250 r.p.m. and another at 1000 r.p.m. The delay period for a given fuel would then be the same. Assume it as being 0.002 second. For the 250 r.p.m. engine the crankshaft would then travel 3 degrees and for the 1000 r.p.m. engine, 12 degrees.

Assume the period of injection in each engine (corresponding to full load) to be 25 degrees. On this basis, at the time of ignition ⅛ of the entire fuel charge is present in the slow speed engine and ½ the charge in the high speed engine. This fuel is, of course, available for spontaneous combustion, and the larger charge may easily result in extra roughness. There may also be unknown chemical phenomena in the fuels occurring during this delay period.

The Delft Engine Laboratory of the Royal Dutch Shell group has been working on this general idea and the results of their experiments were reported by Boerlage and Broeze. Their primary goal was to determine a yardstick for measuring the ignition quality of fuel and to learn what effect, if any, operating conditions had on this characteristic. Their tests were conducted in several engines. With their gasoline experience as a background, they adopted as a reference fuel, one made up of Cetene ($C_{16}H_{32}$) which burned readily, and Mesitylene (C_9H_{12}) which would not ignite under normal conditions. These two fuels were mixed in proportions to give the same results as the sample fuel and the percentage of Cetene in the mixture was used as the "cetene number."

Indicator cards were taken of the second stage or combustion period with definite reference to the open-

ing of the injection valve. In other words, they proposed evaluating a fuel on a basis of its delay period. These cards showed clearly the three stages mentioned and the effect on them of changes in operating conditions and of different fuels.

The hydrocarbon originally used by Boerlage and Broeze was Cetene ($C_{16}H_{32}$). Some difficulty was experienced in securing uniform results with this unsaturated ethylene so Cetane ($C_{16}H_{34}$) was investigated. It is of the paraffin series and while the ignition quality is slightly higher, it has been quite satisfactory as a primary reference fuel. It has been adopted as standard by the Volunteer Group. It is apparent that the Cetane number is here to stay as one of the specifications for present day Diesel fuel. It is a little early yet to predict whether it will be on the basis of Critical Compression Ratio[2] or ignition delay[2]—possibly a combination of the two. It may be that some laboratory routine, such as the Diesel Index[2] (Aniline and Gravity) will be worked out to an entirely dependable formula.

Investigation of these problems has been carried on by a large number of laboratories all over the world and a comprehensive research program was drawn up by a joint committee of the S.A.E. and the A.S.M.E. but it was handicapped through lack of funds and late in 1933 there was formed the Volunteer Group for C. I. Fuel Research. This group numbered sixteen men, and was composed of representatives of oil companies, engine manufacturers and educational institutions. The program of the Volunteer Group is not yet finished, and includes the determination of the influence on various engine factors of: Air temperature; fuel temperature; fuel quantity, total and per injection; air turbulence; carbon deposits; number of successive injections. They also plan to study the development of chemical reactions and physical properties, by which fuels may be judged without resorting to an engine test.

No paper on Diesel fuels would be complete without a tabulated fuel specification and the following are presented as being suitable for present day engines employing solid injection and operating at speeds above 500 r.p.m.:

1. Distillation (End Point), max. 700 deg. F.
2. Cetane number, 40 to 70
3. Conradson carbon, max. 2.0 per cent
4. Viscosity Saybolt, at 100 deg. F., 35-75 sec.
5. B.S.&W., max., 1.0 per cent
6. Sulphur, max., 1.5 per cent
7. Pour Test, 15 deg. F. or as required
8. Ash, max., 0.05 per cent
9. Flash C.O.C., 140 deg. F. or legal
10. Gravity A.P.I., 30 to 40

For engines with operating speeds below 500 r.p.m. and where centrifuging and preheating is not desirable, the specifications could reasonably be modified somewhat as follows:

1. Distillation, 95 per cent at 700 deg. F.
2. Cetane number 40 to 70
3. Conradson carbon, max., 2.5 per cent
4. Viscosity Saybolt U., 100 deg. F., 40-100 sec.
5. B.S.&W., max., 1.5 per cent
6. Sulphur (2 cycle), max., 2.5 per cent
   (4 cycle), max., 1.5 per cent
7. Pour Test, 15 deg. F. or as required
8. Ash, max., 0.1 per cent
9. Flash C.O.C., 140 deg. F. or legal
10. Gravity A.P.I., 25-35

Suitability of fuels concerns the engine builder equally with the refiner. The designer should perfect his engine so that it will properly digest fuels which may be made and marketed economically by the refiner. Availability, price and uniformity are three very important items. It should be unnecessary for the refiner to carry more than two, or at the outside three fuels for all Diesels except those with special treating appliances. Standardization of this sort should reduce the price and improve the availability. This condition can be still further improved by grouping the Diesel and furnace oil requirements. This should be easily within the realm of possibility.

Specifications as shown may be changed with further development both in refining methods and in engine design. A new test engine is being tried out capable of speeds up to 3000 r.p.m. or more which may show us many interesting phenomena at present unknown and unthought of. We may conceivably see the development of a substance for use in unsuitable Diesel fuel which will give it a characteristic similar to an acceptable Cetane value.

The high speed Diesel is in its infancy, but with it comes large volume production and severe competition which always leads to rapid development. This will also react favorably on the slower speed types.

Measure Your Mathematics

CALCULATIONS required of engineers in their daily work sometimes become irksome, not necessarily because they are difficult to perform but they do take considerable time. In many cases factors have to be looked up in some table, perhaps interpolations made, then there are powers and roots to contend with, and the ever present but illusive decimal point.

How much nicer it would be if instead of complicated formulas the engineer were given charts with which the answers can be just scaled or measured off, at least so thinks one reader of Power Plant Engineering. That is not at all impossible, in fact nearly every conceivable mathematical formula used in common power plant practice has been arranged in chart form and published at some time in Power Plant Engineering. Within recent years new principles in the design of charts have been devised making them more simple to use and more accurate in results secured.

Perhaps other readers have had headaches after working over formulas and would like to have their formulas put into the form of charts. If so send them to the Editor, his worry is just what charts are wanted, the designing is just work. The charts that will be published must of course apply to power plant problems only.

EDITOR.

[2]In discussing the results of various investigations, the author, in the original paper, defines these various terms. Stated briefly they are as follows:

Critical Compression Ratio is the ratio at which the ignition of the fuel sample will occur in a given number of injections when using a standardized test engine. It is the method originally developed by Pope and Murdock.

Ignition delay method is the number of crank angle degrees between the opening of the injection needle and the ignition of the fuel, as measured in a standardized test engine. It is the method originally developed by Boerlage and Broeze.

The Aniline Point, as used by Becker and Fischer, is determined by heating equal portions by volume of aniline and the fuel sample in a jacketed test tube to a clear solution and then noting the temperature at which turbidity appears as the mixture is cooled. The gravity of the fuel is introduced to arrive at a "Diesel Index" which is the Aniline Point in degrees F. times the A.P.I. Gravity divided by 100.

Small Diesels Top the Flood

Into the dark, powerless Connecticut Valley Cummins-Diesels bring light, run elevators and air conditioning outfits, and pump pure drinking water.

By P. E. LETSINGER
Vice-President, Cummins Engine Co.
Columbus, Ind.

LONG WILL THE SPRING of 1936 be remembered by citizens in many parts of the country, especially in the torrential river valleys of New England, as the time of the "great flood". Next to the disastrous loss of life and property in an area seriously destroyed by the wild antics of nature, the worst hardships were caused by lack of power—power to supply light, heat, transportation and drinking water.

One of the most devastated spots of the flood areas in March was the Connecticut river valley near Hartford, Conn. Although men had harnessed the river itself to develop power and supply lights and transportation, the work horse of the valley suddenly kicked up his heels and threw destruction on all sides with the greatest turbulence of waters history had ever recorded in Connecticut. Flood stage for the Connecticut river is 16 ft. but when its muddy waters swashed across the streets, literally through homes, into the foundations of buildings there last March even the high water mark of 29.8 ft. for May, 1856, looked like a shallow brook!

When the U. S. weather bureau officially reported that the crest of the Connecticut reached 37.5 ft., men began to understand why that terrifying current of slithering water, topped with the furious white crest, which smote down houses like match boxes, piled up automobiles like tin cans in a Niagara, tipped over oil reservoirs, had brought fear and destruction that Gen. William T. Sherman would have envied. The area around the Hartford district was besmeared with debris.

Fig. 1. A Diesel engine pinch hitting for a motor in the municipal water plant at Cromwell, Conn.

When the last electric power plant in Hartford to be inundated with that stucco of slime and water had to cut off service, the cry from homes, emergency camps, office buildings, hotels, factories, every place human beings were lodged in the darkest hours of the night, the cry came for "candles, and yet more candles."

But these were only minor emergencies. The real need for power was in such vital places as hospitals, where the number of cases naturally doubled and tripled after the gushing waters had smote the valleys and even crept to the crest of the hills; in large office buildings such as the telephone exchange where communication lines had to be kept open; or in water pumping stations where pure water had to be supplied to prevent the rapid spread of disease. Into this breach, when the shivering citizens were calling for candles, into the darkness, went Diesel engines: portable power units, dependable, independent of the elements and with these units came light and power.

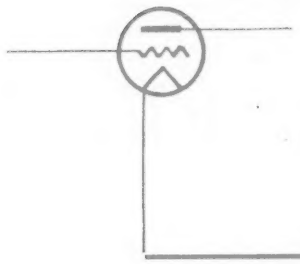
Dispatches dated March 26 revealed the fact that Cummins-Diesels supplied the only lights in the city of Hartford for several days after the flood waters had silenced the last operating engine in a Hartford electric power plant!

Heavy trucks loaded with Cummins-Diesels sloshed and roared their way through the receding waters in the Connecticut valley to Hartford and other communities along the river. These power units were placed on trucks at New York City and hurried into the emergency areas. Other Cummins-Diesels were rushed by express from the factory at Columbus, Indiana, to meet the dire need for light and power in Connecticut.

Working through the night, with only the noisy glare and flicker of acetylene torches and the yellow rays of small bulbs powered by 6-8 v. automobile storage batteries for light, Cummins representatives installed the Diesels. Temporary bases of planks and other makeshift accessories were used successfully to meet the demand for light and power. Empty oil barrels were used for radiators. Despite all these unusual conditions the Disels which could be transported rapidly and installed quickly did the job.

At Cromwell, Conn., 12 mi. south of Hartford, the entire community was supplied with water pumped by a Cummins-Diesel. The pump was formerly operated by

(Continued on page 361.)



PART V. In this article the discussion of the three electrode tube begun in the preceding installment is continued. First, its application as a telephone repeater is described in considerable detail. This is followed by a general discussion of the significance of the negative grid, and finally, a brief discussion is presented on the use of the tube as a voltage, current or power amplifier.

Electron Tubes — Principles *and* Applications

By A. W. KRAMER

THE ENORMOUS IMPORTANCE of the thermionic tube in the world today is the result not so much of its ability to function as an amplifier as it is of the degree to which its amplifying properties can be extended, in other words, of its sensitivity. The idea of an electrical amplifier was not new with the triode. Nearly all relays are amplifiers to some extent and for many years, long before the development of vacuum tubes, the magnetic telegraph relay or "repeater" had functioned successfully on long telegraph lines. The telegraph relay is nothing more than a device to amplify weak telegraph signals so that they can actuate a sounder requiring a relatively large amount of energy. Its principle is, of course, exactly that of the magnetic relay described in the preceding article.[1]

The excellent success attained by this method of repeating or amplifying on telegraph lines, naturally led early telephone engineers to seek a similar device that might be used on telephone lines. The comparatively weak voice currents involved in telephony are rapidly attenuated in their passage over long lines and if the line is made too long and no means is provided to compensate for this attenuation, there will be insufficient energy at the receiving end to actuate the telephone receiver. The development of an amplifying device or repeater for telephone work, therefore, offered an attractive field of research to inventors in the early days of the telephone and many forms of repeaters were produced. The idea involved in these devices is quite simple and closely parallels that of the telegraph repeater. Fundamentally, it involves merely the placing of a microphone contact in operative relation with the diaphragm of a telephone receiver, as shown in Fig. 1. The idea, as can be seen, is simple and it seemed plausible that the very feeble currents received by the telephone receiver would by virtue of the delicate action of the microphone be able to produce comparatively large variations of current in the local microphone circuit and that in this way the amplified voice currents could be sent on to a distant receiving station.

As a matter of fact, however, no gain in volume of transmission was ever commercially effected by this method. Many forms were produced, some of them quite complex as shown by the one in Fig. 2. In this particular design, the receiver diaphragm H operates

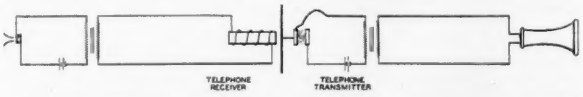


Fig. 1. The idea involved in the early telephone repeater is quite simple. It consists, essentially, in an arrangement in which the diaphragm of a telephone receiver is placed in operative relation with a carbon transmitter unit so that the received impulses actuate the transmitter directly

a balanced valve V^2 which varies the flow of an otherwise constant stream of air flowing through chamber C. The resulting changes in pressure are communicated to the transmitter button T through the flexible diaphragm D. Other types of repeaters operated entirely in vacuum.

Nearly all of these electromagnetic-mechanical repeaters could be made to work perfectly on ordinary telephone lines but none of them had the ability to transmit speech between two distant points any better

[1]Fig. 4a, page 285, May 1936 issue.

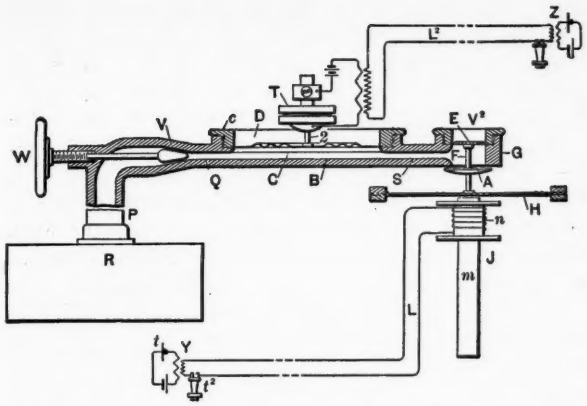


Fig. 2. One of the early forms of telephone relays. This is the Erdman relay in which the received impulse is made to control an otherwise constant flow of air through a chamber covered by a flexible diaphragm. The consequent variations in pressure against the diaphragm serve to operate the microphone

than, or quite as well as, could be done by direct transmission without the use of the relay at all.

The amount of energy received by the electromagnet of the relay is so exceedingly small that it cannot be made to produce the desired mechanical effect upon the microphone contact.

The Vacuum Tube Repeater

All this is merely by way of introduction. It has nothing to do with electron tubes except to serve as a basis for comparison—to show how marvelously sensitive the electron tube is compared to these early attempts to produce amplifiers. Today all these early telephone relays are matters of history; they have all been consigned to oblivion by the advent of the electron tube. In the development of the three electrode tube described in the preceding chapter, the telephone

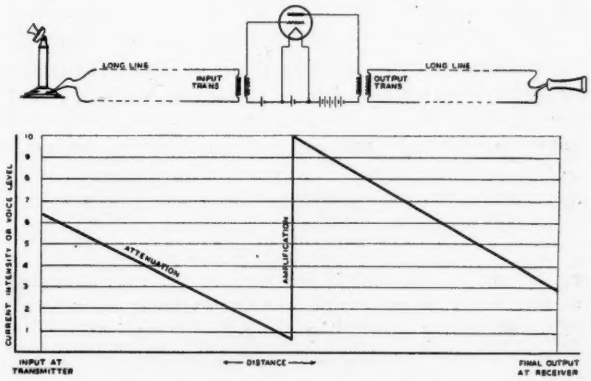


Fig. 3. Simple diagram showing the application of the triode amplifier as a telephone relay or "repeater". Below is shown the variation in voice current intensity along the line

engineer at once had a telephone repeater, so sensitive, so astonishing in performance that almost overnight the limits of telephone transmission were extended to the farthest corners of the earth—around-the-world telephony became an actuality.

At the risk of becoming tedious, we will consider briefly the specific application of the three-electrode amplifier in telephony as a repeater. In an ordinary telephone line, the voice current falls off in intensity very rapidly as the length of the line increases. For local communication this is not a serious matter but for long distance telephoning it is decidedly a limiting feature. To overcome, or rather to compensate for, this attenuating effect of the resistance of the line on the current, vacuum tube amplifiers are placed in the line at various intervals. These amplifiers, or repeaters as they are called, are exactly like the amplifier described in the preceding chapter.[2] Their principle of operation is more adequately explained by Fig. 3 which shows a single repeater in a telephone line and below it a graphical representation of the voice current intensity along the line. The voice level at the transmitter is assumed to be about 6.5 units. As this voice current travels over the long line, its intensity diminishes steadily with increasing distance until at the input to the repeater station it has an intensity of about 0.5 units, an amount, it can be assumed, too small for the operation of even a sensitive telephone receiver. At the repeater station, however, the electron tube amplifier amplifies this weak current to a value even higher than the original input at the transmitter; it is amplified to 10 units whereas the original input was only 6.5. This is entirely possible with the electron tube repeater.

This amplified current is now sent out over a further stretch of line where again it suffers attenuation but arrives at the receiver with an intensity of almost three units, sufficient to actuate the telephone receiver.

This is perhaps the most important application of the electron tube amplifier that can be cited. It is used on every long telephone line in the world and in this

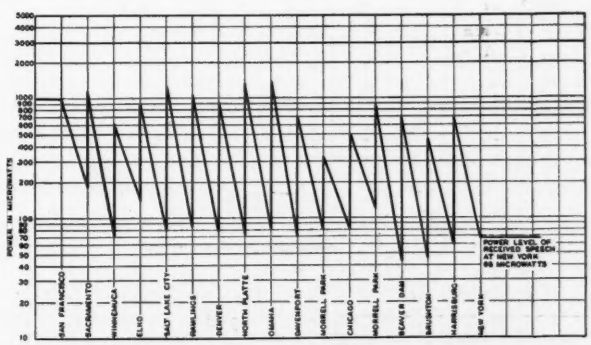


Fig. 4. Power levels of the San Francisco-New York long distance telephone line, showing the effect of the repeaters. With 1000 microwatts input at San Francisco the voice current power level drops so slightly under 200 mw. at Sacramento. Here the current is amplified by vacuum tube repeaters to a value of over 1000 mw. This new high level falls to 70 mw. by the time it reaches Winnemuca where it is again amplified. Thus the voice current is amplified successively 15 times before it reaches New York City

country, transcontinental telephony would be impossible without it. On the New York-San Francisco telephone line, the voice currents are amplified some fifteen times in this manner, as shown by Fig. 4. The intensity of the voice current can be controlled to any desired extent, the received current at New York often

[2]Fig. 11, page 288, May 1936 issue.

being higher than it was when it left San Francisco. At each repeater station, the gain in intensity is effected by an addition of power supplied from local batteries or generators.

Suppose No Repeaters Were Used

It may be of interest to consider what the power input to a long line would have to be if the repeaters were not used, assuming that this could be possible. On the San Francisco-Havana line, for example, with the transmitter delivering 1000 microwatts at San Francisco, the power received at Havana at the end of the 5500 mile circuit in commercial practice is about 25 microwatts. If there were no intermediate amplifiers, and assuming that the line could carry unlimited power without burning up, it would be necessary, in order to deliver 25 microwatts at Havana, that power sufficient to light an ordinary 60 watt incandescent lamp be flowing in the circuit at some point in North Carolina, while at Philadelphia the power in the line would be 5 kw. A little east of Denver the line would be carrying the equivalent of all the electrical and mechanical power generated in the world (enough to light 20 billion electric lamps). This is about 1/200,000 of the power which is received by the earth from the sun. Yet at Sacramento all of this power (200,000 times all the power generated on earth) would have to be flowing in the line to produce 25 microwatts at Havana.[3]

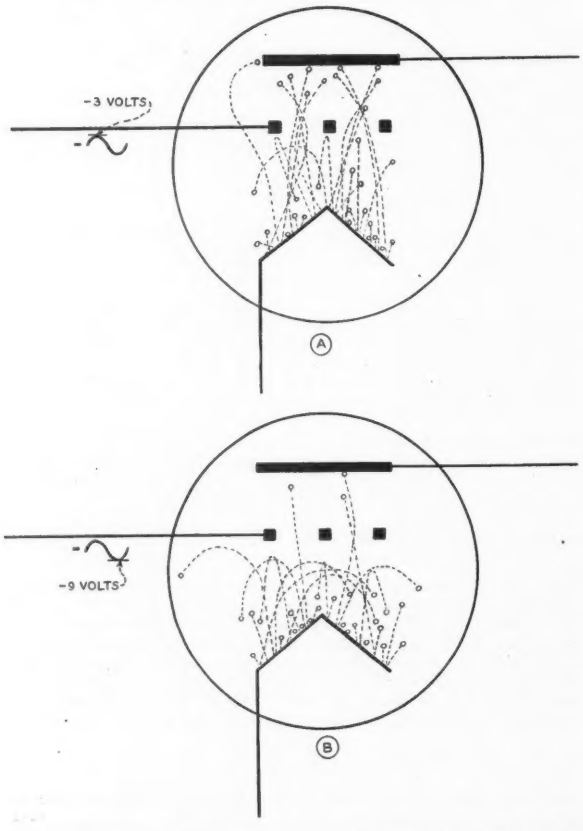


Fig. 5. Two diagrams which attempt to show the effect of varying negative potentials on the grid upon the cathode-anode current. "A" represents an instantaneous picture when the grid potential is 3 volts negative. Although the grid repels the electrons most of them get through the grid and reach the plate. At "B", however, where the negative grid potential is 9 volts, the repelling influence of the grid is much stronger and very few electrons reach the plate

So much for the telephone repeater. Our reason for considering it in such detail is that it is an extremely important application of the electron tube amplifier and one in which its capabilities have been demonstrated in over 20 years of increasing use.

Other applications are not fundamentally different. If this application is understood one should have no difficulty in understanding ordinary industrial applications where, in most instances, the requirements are not nearly so exacting. Further applications will be discussed later.

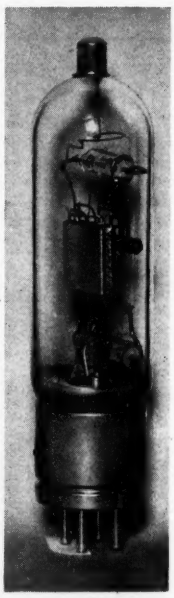


Fig. 6. The FP-54. This tube when properly used in so sensitive that it can measure currents as low as the passage of 6 electrons per second

The Grid Draws No Electrons

The superiority of the electron tube amplifier over all other forms of electrical amplifiers lies in the fact that *the grid draws no electrons* when it is maintained at a negative potential. The significance of this statement must be fully understood for it explains the tube's marvelous sensitivity. Although the grid draws no electrons when maintained at a negative potential, variations in this negative potential *do* cause variations in the plate current. Hence it is possible for a voltage representing practically no energy to control a relatively large space current and to develop a corresponding quantity of electrical energy in the plate circuit. Furthermore, the tube is capable of amplifying voltages of all frequencies up to the highest used in radio communication, i.e., up to well over a hundred million cycles per second. And by using two or more tubes in series, or "cascade," almost any degree of amplification can be obtained.

We have already considered the action of the triode amplifier in some detail but to show more clearly that the grid draws no electrons when maintained at a negative potential, we have drawn the two diagrams shown in Fig. 5, A and B. These, of course, are purely hypothetical but they attempt to show the paths of electrons under two different values of negative grid potential, i.e., —3 v. and —9 v. At A, which shows conditions in the tube at the instant the grid potential is, say, —3 v. (with respect to the cathode), nearly all of the electrons emitted by the cathode reach the plate. Their paths are curved due to the repulsive influence of the negatively charged grid wires, but this negative charge is not sufficient to prevent them from getting through the openings of the grid.

At B a different condition prevails. Here, conditions are depicted at the instant when the grid potential has swung to —9 volts. The repulsive influence of the grid is now very much greater than it was in the first instance; as a consequence, very few electrons manage to get through to the plate; most of them are

[3]Telephone Transmission over Long Lines. H. S. Osborne. Transactions of the A.I.E.E. Vol. XLII, p. 984.

turned back towards the cathode. This condition represents low plate current. Case A represents high plate current.

All this, of course, was pointed out in the preceding chapter though in less detail. But note that in neither of these cases do any electrons flow to the grid,—the grid repels them all. This is the important fact to

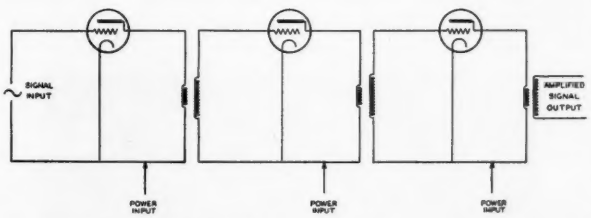


Fig. 7. Simplified diagram showing amplifiers connected in cascade

remember for, since no electrons are captured by the grid, no current flows in the grid circuit, and since no current flows in the grid circuit, practically no energy is necessary to effect the control of the plate current we have described.

We say no current flows in the grid circuit. From an absolute standpoint this is not strictly true. If the grid undergoes variation in negative potential, there must be some surging back and forth of electrons between the ends of the "open" grid circuit. This, of course, constitutes a current and requires energy but in practice this energy is so small that it is practically negligible. Indeed in some electron tubes this grid current is expressed not in amperes or milliamperes or even microamperes, but in terms of *electrons per second!*

In the FP-54 tube[4], for example, the sensitivity is so great that with suitable circuits current of 10^{-18} amperes can be measured. In terms of electrons, this current represents a flow of approximately *six electrons per second!* This, of course, is unusual but compared to any other form of electrical device, even the ordinary electron tube used in commercial applications, is extremely sensitive. It must be clearly understood, however, that the condition of zero grid current holds only as long as the grid is maintained negative with respect to the cathode. The instant the grid becomes positive (as it does in some applications) it attracts electrons and current will flow in the grid circuit. In all instances, however, this grid current is very small compared to the anode current. The grid in all cases (whether positive or negative) exercises control over the anode current.

From the foregoing, it should be clear that the electron tube amplifier is essentially a device for controlling the power from a local battery by means of small (infinitesimal) voltages applied to the grid. This process of amplification is, of course, perfectly consistent with the law of the conservation of energy; it involves no mysterious gain in power nor any other process that cannot easily be explained. The amplified output of one tube can be applied to the input of a succeeding tube and the amplified output of this tube in turn can be applied to still another tube and so on until almost any desired degree of amplification is obtained. In each stage, as shown in Fig. 7, a local battery or other source of power supplies the necessary additional energy.

Voltage Amplification

The electron tube, furthermore, can be used as an amplifier to accomplish different purposes; it may be used to amplify voltage, or current or power, whichever is necessary. These different functions are obtained largely by the design of the load into which the tube operates. In the preceding chapter[5] for example, brief reference was made to the effect of a load resistance in the plate circuit—that it caused the tube to function as a "voltage" amplifier.

A specific example may explain this more effectively. In the circuit shown in Fig. 8 which is a conventional amplifier circuit, with instruments included

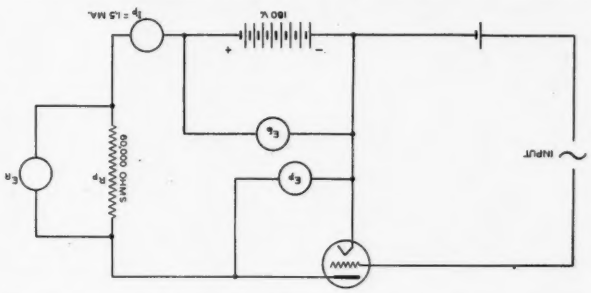


Fig. 8. Amplifier circuit showing instruments to measure currents and voltages at various points

to measure voltage and current at required points, a load resistance of 60,000 ohms is included in the plate circuit. Assuming a plate current of, say, 1.5 milliamperes, the voltage drop across this resistance is given by Ohm's Law:

$$E_R = I_p \times R_p$$
$$= 0.0015 \times 60{,}000$$
$$= 90 \text{ v.}$$

Since there is a drop of 90 v. across the resistance R_p and since the battery voltage is 180, it is evident that the voltage E_p across the plate-cathode is $E_b - E_R$ or $180 - 90 = 90$ v.

Suppose, now, that by varying the grid voltage by 1 volt the plate current becomes 2 milliamperes. The corresponding voltage drop across the resistance R_p now becomes $0.002 \times 60{,}000 = 120$ v., a change of 30 v. Since a change of 1 volt in the grid circuit thus produces a change of 30 v. in the plate circuit, we have an actual voltage amplification of 30.

With the same current and voltage conditions, if the resistance R_p had been made 80,000 Ohms instead of 60,000, the voltage change would have been 40 v. Thus it appears that the greater the load resistance the greater the amount of voltage amplification. With infinite resistance the voltage amplification would be a

[4]The FP-54 is a specially designed high vacuum electron tube in which a special effort has been made to reduce all losses to a minimum. As shown by Fig. 6 there is nothing unusual or distinctive about the appearance of this tube except that the grid structure is supported on quartz beads. This tube has the distinction of being entirely impractical. Its applications, present and future, probably are purely scientific. It counts cosmic rays. It measures, in cooperation with the photoelectric cell, the light from distant stars, being able at present to detect the light from a star of the 14th magnitude. It records the fragments—neutrons, protons and alpha particles—of atomic nuclei smashed by high speed ions.

[5]Page 286, May issue.

maximum but, of course, it is impossible to obtain this condition. In practice as the resistance is increased the potential drop across it is so great that in order to impress a sufficiently high potential between the plate and the filament of the tube, and to obtain appreciable current, it is necessary to use a very high battery voltage, which is generally undesirable in practice and frequently difficult to obtain. Accordingly, other methods are used but these will not be discussed at present. The thing we wish to impress here is that the function which the tube fulfills is determined by the resistance of the load circuit. In general, when a tube is required to amplify voltage, it works into a high resistance load.

When *current* is to be amplified, as might be expected, the tube works into a very low resistance. Similarly, a *power amplifier* requires a medium load resistance, usually on the order of a few thousand Ohms.

These separate functions of the thermionic tube will be considered in detail in subsequent articles.

Doubles Diesel Capacity in Same Space

ADVANCES in Diesel engine design and construction are forcefully brought out by a new engine, built to replace a unit in a motorship, and which doubled the power of the vessel in the space occupied by the original unit. The new engine, rated 4000 br.hp. at 109 r.p.m. is of the double-acting, two-stroke, four cylinder type, with a bore of 27½ and a stroke of 47½ in. It was built by Richardsons, Westgarth and Company for the motorship Silverlarch of the Silver Line.

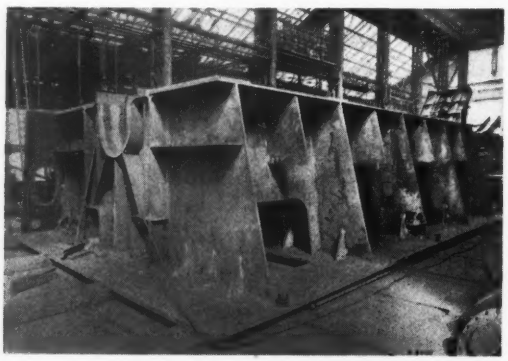


Fig. 1. Bedplate of new Diesel before applying side and end plates. Arc welding permitted 33 per cent savings in weight (Photo courtesy The Lincoln Electric Co.)

Construction of an engine having such a high ratio of power to size has been made possible by improved design employing steel and electric welding. Major parts such as bedplate and columns, as well as scavenging air main, crankcase covers and plates and exhaust pipe, are all built of steel plates arc welded with Fleetweld electrodes.

The bedplate is of special interest in view of the engine's power and its comparatively low speed. The length of the bedplate is 22 ft. 6 in., width 14 ft. and depth 5 ft. 4 in. It is of the tank-top type. The bottom plate consists of two lengths of steel plate double butt-welded together longitudinally. To obtain maximum rigidity, the sump is welded integral with the bedplate. The cast steel bearing housings are fixed in the bedplate by steel plates welded to them and to the sides and bottom of the bedplate.

Although the aim of the builder was to obtain a structure of maximum rigidity at moderate cost without any particular emphasis on lightness, the saving in weight was large. The bedplate weighs approximately 33 per cent less than would be possible with suitable cast iron construction. Actual weight, arc welded, is 29½ t. Weight, in cast iron, would have been 44 t. Cost savings were also considerable due to elimination of patterns and pattern drawings and to simplified machining.

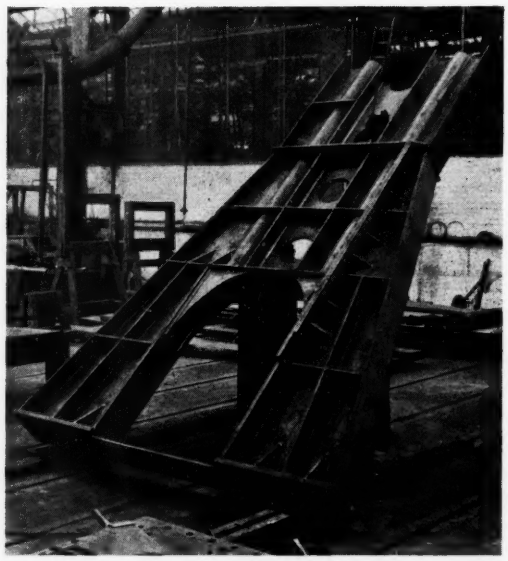


Fig. 2. One of the main columns, built entirely of arc welded steel (Photo courtesy The Lincoln Electric Co.)

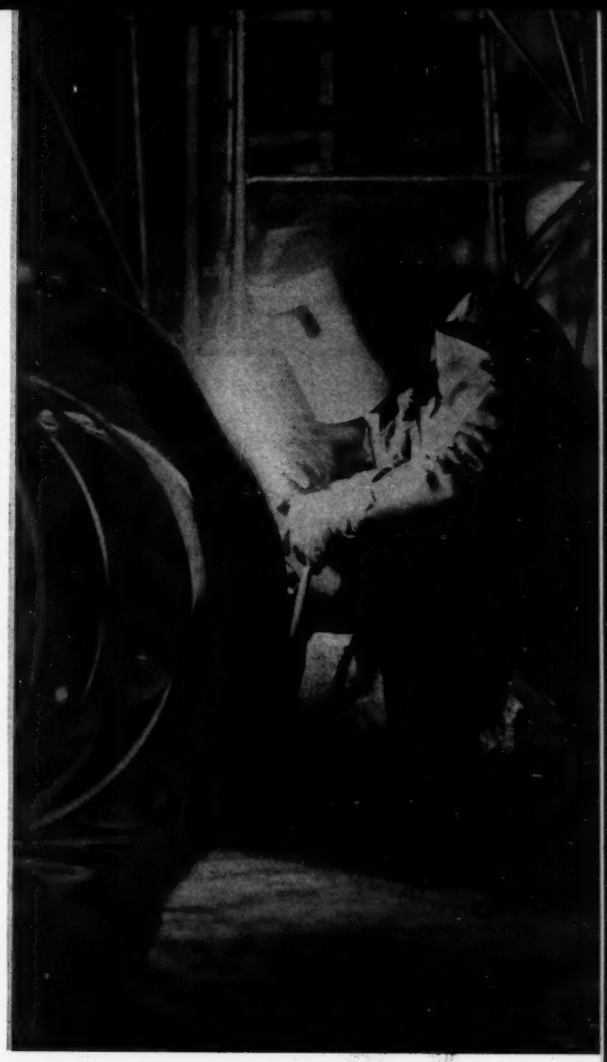
Latest Transparent Wrap

TREE ROOTS, pushing through the outer surface of a new protective coating for underground pipe, skid on the surface of a transparent wrapper and turn harmlessly away. The novel coating was not originally intended for this purpose, but had as its main objective protection from soil stresses that formerly cracked the protective layer and permitted corrosion. Other advantages such as high electrical resistance have been found.

Thirty miles of pipe have been laid experimentally with the new coating, and "Western Gas" reports encouraging results. The pipe is first coated with asphalt, then two separate layers of Kodapak (Eastman's cellulose acetate transparent film), followed by more asphalt and, finally, paper. When this wrapping is squeezed or rubbed by the surrounding soil, as when the pipe contracts or expands, the two layers of Kodapak slide on each other and the underlying protective coat of asphalt remains intact. Recent inspections indicate additional life for pipe so wrapped.

ARTHUR D. LITTLE, INDUSTRIAL BULLETIN.

WELDING *Transforms the* Condenser



Welded Steel Shells are adaptable and practicable. Welded joints simplify condenser construction with reduced weight and enabling tubes to be rolled at both ends for minimum leakage.

By M. L. CARSON

Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

INDIVIDUAL power house designs differ greatly and this prevents condensers from being completely standardized, therefore each installation must be adapted to the requirements of the particular job. Condensers of welded steel construction frequently fit better into this situation because of their greater flexibility in design. This does not mean that the cast iron shell type may not, in certain cases, be more desirable for a given installation, but the welded design does greatly increase the number of sizes and variations available, with less pattern expense, and, therefore, often at less total cost. Moreover, since welded steel construction lends itself better to shorter shipments, the latter requirement itself often determines the design purchased. In other cases where distant shipment, or ocean transportation, is involved, the approximately 25 per cent lighter weight of welded steel condensers may be the deciding factor for building a particular size of this construction.

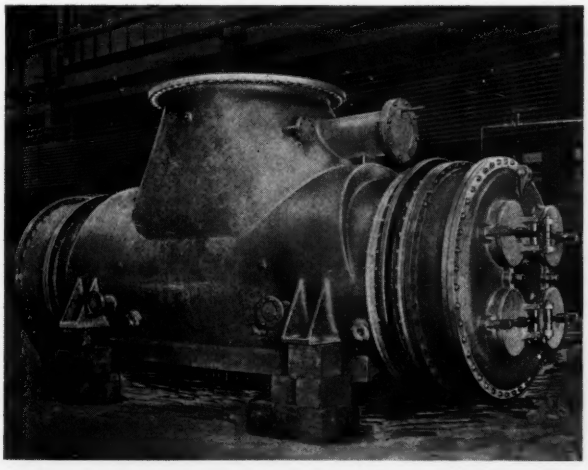


Fig. 1. 7500 sq ft., two pass, condenser with welded steel shell, cast iron water box and welded steel expansion joint

A typical Allis-Chalmers steel condenser shell is shown by Fig. 1. The large dome provides effective steam distribution while the flaring exhaust connection offers unlimited possibilities in adapting the condenser to the particular job in hand and, being welded right into the dome, avoids one vacuum joint. This two-pass condenser 16 ft. long, contains 7500 sq. ft. of surface.

Rates at which boilers are being fired today, together with the use of higher steam pressures and temperatures, makes it essential that boiler feedwater contain little or no scale forming ingredients. As a step in the reduction of such feedwater contamination, condenser manufacturers are furnishing machines with tubes rolled into the tube sheets at both ends. A typical assembly is shown by Fig. 2. The belled venturi entrance is provided at the inlet end of the tubes to reduce entrance loss. In the single pass condenser the venturi entrances are necessarily all at one end of the shell but in the multiple pass condenser they are belled at whichever end the water enters the tubes.

Material used for tubes ordinarily depends on the nature of the water encountered. For normal operation non-corrosive inland water the use of Muntz metal (60 copper, 40 zinc) is common. For salt water or other ordinary corrosive water Admiralty metal (70 copper. 29 zinc, 1 tin) is generally used. Where some extremely

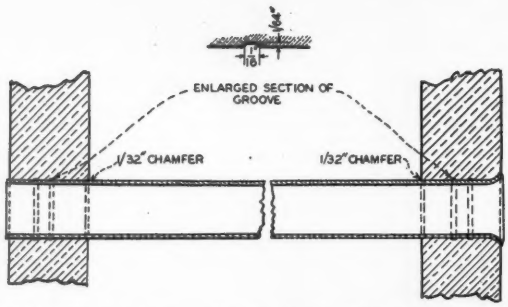


Fig. 2. Condenser tube assembly showing method of rolling-in tubes at both ends and typical belled Venturi inlet

corrosive water is encountered due to some acid condition, a special composition may be required.

If tubes are rolled at both ends provision must be made for tube expansion. In Allis-Chalmers condensers this expansion is taken care of by a patented joint of the welded type made of corrosion resisting steel. Such a joint is used on the condenser illustrated in Fig. 1, while Fig. 3 shows the details of construction and installation of the joint. One flange of the joint bolts to the shell flange. The other flange bolts to the water box flange with the end tube sheet bolted between them.

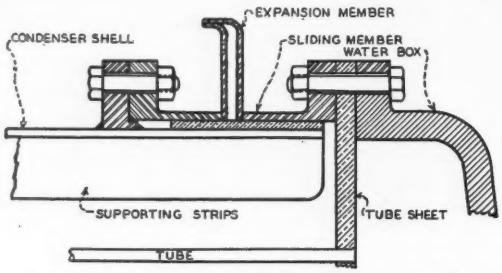


Fig. 3. Allis-Chalmers expansion joint showing its relation to the condenser shell, the tube sheet and the water box

The strain due to the movement of expansion is taken in the bend of the expansion member and not at the tip where the expansion member is welded together.

With the arrangement shown the tube sheet and water box on that end become a floating member. Provision must be made for carrying the weights of this floating member as this amounts to a considerable item and must not be overlooked. Where this particular type of joint is used the condenser shell is extended and provided with bronze wearing strips on which the weight of the floating member is carried. The extended shell with its bronze wearing strips and reinforcing placed under the top of the shell to help support the floating members is shown by Fig. 4. The inner diameter of the

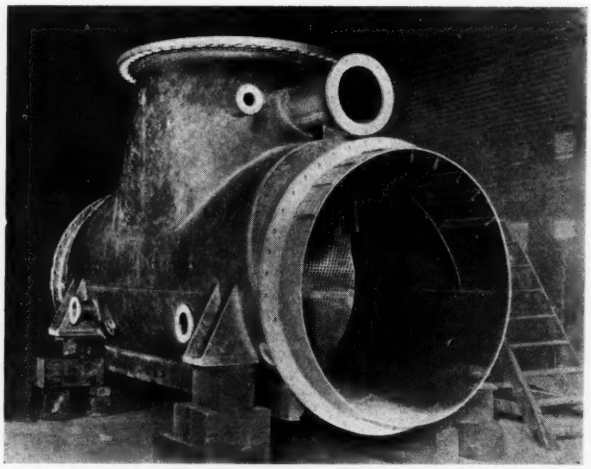


Fig. 4. Welded steel condenser showing long lip extension with bronze wearing strips for supporting expansion joint and floating end

expansion joint is bored and the bronze wearing strips are turned to furnish machined surfaces for ease in movement of the floating member.

When the shell, with the expansion joint and tube sheets, is assembled, prior to expanding in the tubes, the entire expansion joint is compressed a predetermined amount to simulate as closely as possible its normal operating position. This definite face to face distance for the expansion joint is maintained when rolling in the tubes. It will be readily seen from the illustrations how this expansion joint functions to permit the relative expansion between the tubes and the shell. Furthermore, with this external arrangement of the ex-

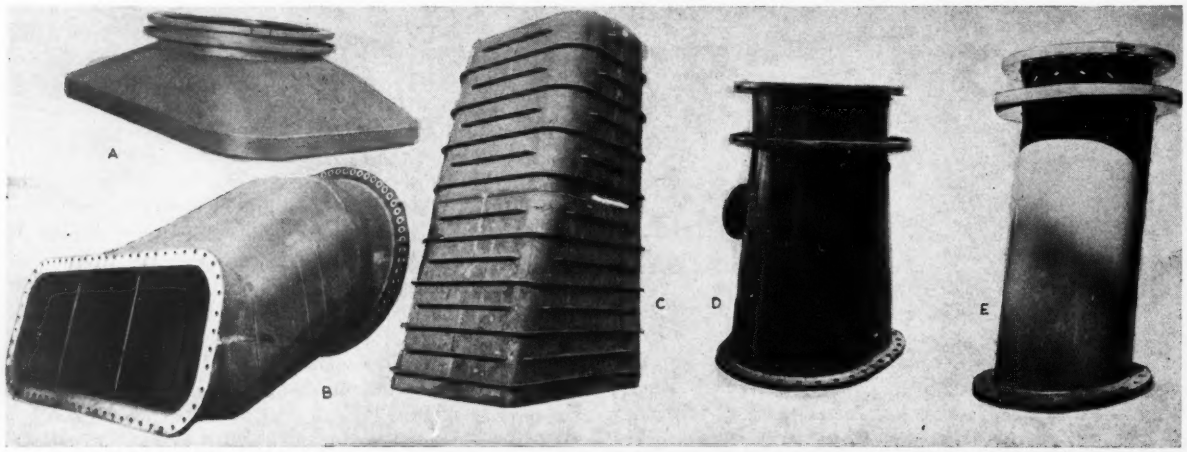


Fig. 5. Groups of connections showing versatility of welding

pansion joint in reference to the shell the expansion joint is accessible at all times.

This welded steel shell construction can be used in connection with small sizes of condenser shells as well as for larger ones and the exhaust connection of a welded steel condenser can be adapted to the individual needs of an installation as shown by Fig. 5. The length of the exhaust connection applying to a given condenser shell is limited only by shipping requirements.

In cases where the vertical expansion of a condenser is not taken care of by foundation springs, an expansion joint is sometimes utilized to advantage in the exhaust connection. This can often be done without having another vacuum joint by making the expansion joint an integral part of the exhaust connection as in Figs. 5D and 5E. Figure 5A shows a similar application of this expansion joint, in a special case where the exhaust connection is quickly changed from the small round turbine exhaust nozzle to a rectangular shape where it joins the domes of the condenser shell. The welded construction adapts itself readily to almost any variety of connection requirements.

Orders Should Be Written

By Mark Bell

OPERATION in a modern power plant is a far more complicated business than it was some years ago. The increase in the number of auxiliaries, the improved, albeit more complex, methods of treating feedwater, the care and maintenance of the various meters; all these items call for more exact operation all along the line. It follows, as a corollary, that orders and instructions, given by those in charge, must be fully understood and correctly carried out. To ensure this it is imperative, for the protection of all concerned, that they be placed in writing.

Some well run companies have a short reminder on every sheet of paper used by them in their business. It reads: "Always put your orders in writing. Verbal messages may be forgotten or misunderstood." This is very sound practice and tends to promote efficiency. The executive, before signing his name to anything, will make quite sure that the contents of the message are in accordance with the facts. The receiver of the message will have no chance to misunderstand and, should anything go wrong, will be able to produce documentary evidence and authority for his action. Every order should be in duplicate with a carbon copy left with the sender.

Following this writing argument a little further we come to the entering of changes in the log book. Passing along orders orally from one shift to another is most unsatisfactory and will, sooner or later, lead to trouble. Nobody's memory is infallible and, whilst at the best, a verbal instruction may be forgotten, at the worst, if trouble develops, an unscrupulous person may wriggle out of the consequences by blaming the other party for incorrect instructions given.

Any major change in normal operation should be noted on the log sheet or in the day log book. If, for example, the steam to the spare boiler feed pumps is shut off at the header as well as at the throttle, this should be noted. If any piece of equipment is taken out of service for any reason, this fact should be noted. On the face of it these things appear elementary but every operator knows instances where valuable time has been lost owing to some such omission.

When, as occurs in modern plants where telephones connect the turbine room, boiler room and other stations, orders are given orally, always insist that the receiver repeat the order. This will show the giver that he is understood and, at the same time, impress the order upon the mind of the receiver.

Still another instance where writing gives added efficiency is where a mishap has disrupted normal operating procedure. Should steam pressure drop, owing to plugging of a pulverizer or failure of the boiler feed pump, should power load be interrupted through any cause; always, as soon as matters straighten out, get all concerned to write a report of their own particular part in the operation. These reports will be for the information of the chief engineer. These reports need not be, primarily, for the purpose of affixing blame or responsibility. Rather, they will allow the chief engineer to detect weak links in equipment and operating schedule and permit of his rearranging or altering conditions to guard against similar failure in the future.

He, in his turn, should write a report, based on those of his subordinates, and append his recommendations, and this report should be read and noted by all the operating force. In this way every operator will be fully conversant with the remedy for this particular condition and will be able to cope with it, promptly, should it happen on his shift.

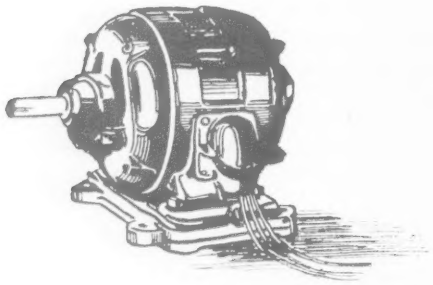
Diesel Costs

OPERATING RECORDS of the municipal Diesel power plant at La Crosse, Kans., have been compiled for a period of 15 years and show a total operating of 1.1 ct. per kw-hr. The plant consists of three De La Vergne engines: one 125-hp. engine installed in 1916; one 260-hp. engine installed in 1922; one 330-hp. engine installed in 1928.

Over the 15 yr. period a total of 10,184,906 kw-hr. were generated at a total operating cost of $112,258.42. This operating cost was made up as follows: Fuel cost, $39,772.41; lubricating cost, $6,714.16; repairs and supplies, $9,914.31; labor, $55,857.54. This last item includes $381.82 labor chargeable to overhauling the engines.

During this period 1,053,847 gal. of fuel oil and 12,561.9 gal. of lubricating oil were used. The 15 yr. average was 9.66 kw-hr. per gal. of fuel oil, which includes the oil used for office heating. The average yearly cost for repairs and supplies was $655.00 or 92 ct. per installed horsepower. The 260-hp. engine installed in 1922, and in continuous service since, received its first general overhauling in 1933.

Operating Characteristics



Effect of excitation. Comparison with induction motors. Variation of power factor with load. Power factor correction, methods of calculation. Operation of synchronous motors at constant power factor.

By GORDON FOX

Vice President, Freyn Engineering Co., Chicago.

IN THE OPERATION of synchronous motors it is a well known fact that either magnetizing or demagnetizing wattless current can be taken from the supply system, depending upon the degree of direct current excitation. Thus it is possible to govern the power factor of the motor by adjusting the field current. This is a unique characteristic and is one of the most important attributes of the synchronous motor.

Synchronous motors may be operated to carry mechanical load only, or as synchronous condensers for power factor correction or voltage regulation with no mechanical load, or the may perform both services simultaneously. The degree of excitation required, depends upon the service for which the machine is intended.

Fig. 1 gives the so-called V curves of a synchronous motor. These curves show how the stator current changes with different degrees of excitation. With a given load, a definite excitation results in minimum armature or stator current. This condition corresponds to 100 per cent power factor. At other excitation values there is more or less lagging or leading wattless current, the amount depending upon the departure from unity power factor excitation. These curves show the relations for no load operation, for operation with half rated mechanical load and with full rated mechanical output.

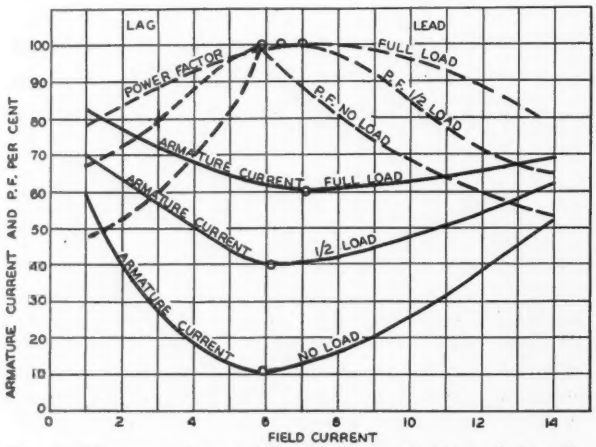


Fig. 1. V curves of a synchronous motor, showing relations between excitation and armature current and power factor

The shape of the V curves depends largely upon the value of armature reaction, the curves coming to a sharp point for minimum input and rising rapidly on either side with slight change of field excitation in the case of a machine with low armature reaction. The curves are much flatter in the case of a motor with high armature reaction.

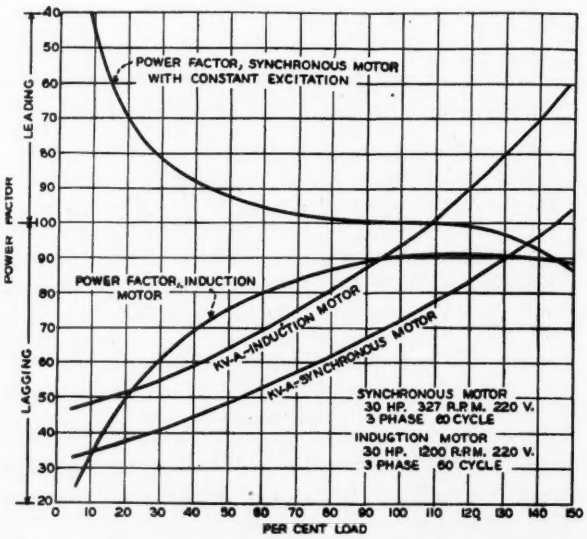

POWER FACTOR, SYNCHRONOUS MOTOR WITH CONSTANT EXCITATION
POWER FACTOR, INDUCTION MOTOR
KV-A-INDUCTION MOTOR
KV-A-SYNCHRONOUS MOTOR
SYNCHRONOUS MOTOR 30 HP. 327 R.P.M. 220 V. 3 PHASE 60 CYCLE
INDUCTION MOTOR 30 HP. 1200 R.P.M. 220 V. 3 PHASE 60 CYCLE
POWER FACTOR
LEADING
LAGGING
PER CENT LOAD

Fig. 2. Relation of power factor and load in synchronous and induction motors.

When a synchronous motor is operated to carry mechanical load only, its field is best excited to such a point that the power factor is unity. The absence of wattless current permits minimum current input and highest efficiency under these conditions. As the mechanical load changes, the power factor will vary slightly. A machine may have a slightly leading power

of Synchronous Motors

factor with a given excitation under light load. As the load increases, the rotor poles fall back so that they are not so nearly opposite the stator poles and their magnetizing influence is less effective. Unity power factor conditions will then be approached. Still further increase of load may even cause a lagging current. Since operation is more stable with over excited fields and since the power factor tends to lag with increase of load, it is sometimes advisable to slightly overexcite the fields, particularly with fluctuating loads.

Comparison with Induction Motors

The manner in which the power factor of a synchronous motor varies, with changes in load, is shown

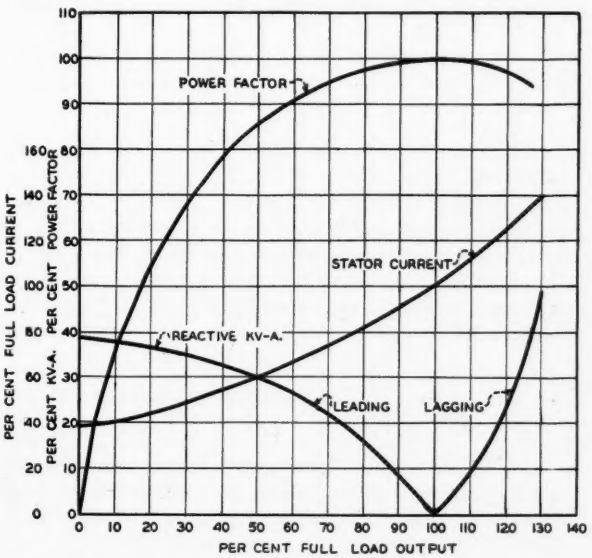


Fig. 3. Relations of power factor, armature current and reactive kv-a. in a synchronous motor

in Fig. 2. The excitation of this motor is constant and is set at that value which gives 100 per cent power factor with full mechanical load. The kv-a. input to the motor is also shown. By way of comparison, the power factor and input curves for an induction motor are also shown. The difference in power factor with fractional loads is particularly marked. The kv-a. input to the induction motor is appreciably higher at all loads.

The relations of power factor, armature current and reactive kv-a. are shown in somewhat different form in Fig. 3. These curves apply to a motor carrying constant excitation at a value causing 100 per cent power factor at full load.

Synchronous motors which are to be used to drive a mechanical load, with no power factor correction

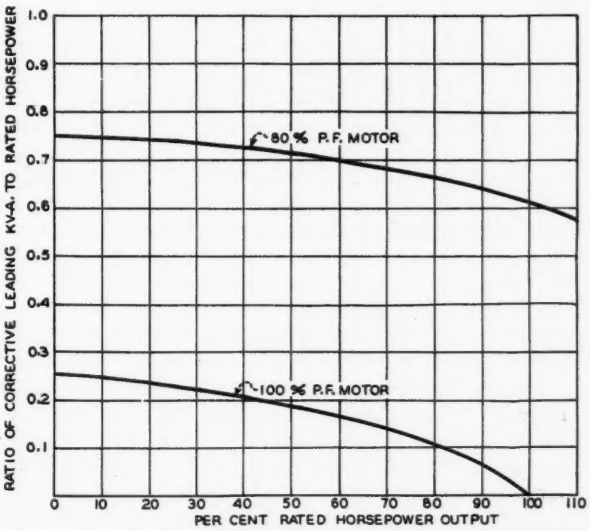


Fig. 4. Wattless kv-a. which can be supplied by a synchronous motor rated on 100 per cent and on 80 per cent power factor basis

other than that resulting from addition of unity power factor load to the system, are rated on a 100 per cent power factor basis. They are designed for operation with excitation giving 100 per cent power factor with full mechanical load. Motors which are to be used for power factor correction by delivering wattless current to the system are sometimes rated on the basis of 90 per cent power factor but more commonly on the basis of 80 per cent power factor. These figures signify the power factor with normal excitation and with full mechanical load.

The unity power factor motor having moderate starting, pull-in and pull-out torque values (about 50 per cent starting torque, 41 per cent pull-in torque and 150 per cent pull-out torque) is the most economical synchronous motor. The stator windings carry minimum current, due to the high power factor, hence can be of minimum section. Due to the limited excitation necessary the field capacity required is also minimum.

If a synchronous motor is to be used for combination service, to carry a mechanical load and also to correct power factor, it must be larger than if it were to perform either service alone. The armature conductors must be heavier because of the increased current and the fields and field windings must be heavier because of the increased excitation and flux. Table I gives a general idea of the relative size, weight and performance of synchronous motors rated on 100 per cent and on 80 per cent power factor basis. Thus a given frame will have about 30 per cent lower horsepower capacity and 2 to 3 per cent lower efficiency if rated on an 80 per cent power factor basis than if rated on 100 per

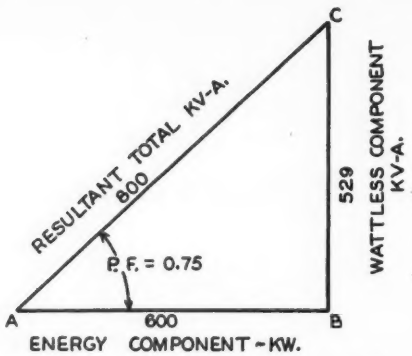


Fig. 5. Vector diagram showing power relations

cent power factor basis. Conversely, for a given horsepower capacity, a motor rated on 80 per cent power factor basis will be 10 to 50 per cent heavier, it will develop 40 to 50 per cent more starting torque and 110 to 140 per cent more pull-out torque, and it will operate at 1.5 to 2.5 per cent lower efficiency. Because of their greater size, higher cost and lower efficiency, the use of motors rated on 80 per cent power factor basis should be confined to those applications where the resultant power factor correction warrants the cost thereof. Where power factor correction is essential, the synchronous motor serves a dual purpose effectively and at relatively low additional cost.

When a synchronous motor is carrying load at 100 per cent power factor, no wattless current flows, the current is all effective in producing mechanical output (less losses). If the motor were to operate as a synchronous condenser at low power factor, the current would be nearly all wattless. With combined service, both load and wattless components exist. The approximate amounts of wattless kv-a. which can be supplied by synchronous motors rated on 100 per cent and on 80 per cent power factor basis, are shown in Fig. 4. The exact amounts depend upon design factors of individual motors. It will be noted that when a 100 per cent power factor motor carries 70 per cent load, with normal excitation, about 12 per cent of the kv-a. input rating of the motor will be delivered as wattless current. When an 80 per cent power factor motor carries 70 per cent load, with normal excitation, about 70 per cent of the kv-a. input rating of the motor will be delivered as wattless current.

Motors designed for unity power-factor operation are generally rated on the basis of 40 deg. C. rise in both stator and field windings. Motors designed to have high pull-out torque are sometimes rated for 50 deg. C. rise in the field windings. Motors designed for 80 per cent power factor operation are commonly rated for 40 deg. C. rise in the stator and 50 deg. C. rise in the field windings. This is due to the fact that the stator current increases with increased load but the field current remains unchanged.

Power Factor Correction

The principles of power factor correction involve only the simplest elements of vector analysis. These principles can be best illustrated by a few examples.

An alternating current load may be considered as made up of two components. The energy component is in phase with the voltage; the wattless component lags 90 degrees behind the voltage. In Fig. 5, AB represents the energy component and BC the wattless component. The total load is the resultant of these two components and is represented by AC. This triangle forms the basis of solution of power factor problems.

Example No. 1. To represent graphically a system delivery 600 kw. at 75 per cent power factor.

$$\text{Total kv-a.} = \frac{\text{kw.}}{\text{P.f.}} = \frac{600}{0.75} = 800 \text{ kv-a.}$$

In Fig. 5 lay off line AB to some scale to represent 600 kw. Since the wattless component is 90 deg. from the energy component, erect a perpendicular at the point B. With A as a center and a radius equal to 800 kv-a. (to the same scale as AB) describe an arc which cuts the vertical at C. The wattless component of the system is BC, which, by measurement, is found to be 529 kv-a. The angle between AB and AC is such that AB/AC = 0.75, which is the power factor of the system.

Example No. 2. What is the effect of adding to this system a synchronous motor having 250 hp. load at 100 per cent power factor?

$$\text{Motor input} = \frac{\text{hp.} \times 0.746}{\text{Efficiency}} = \frac{250 \times 0.746}{0.93} = 200 \text{ kw.}$$

This power load is a direct addition to the energy component of the system. In Fig. 6 BD is therefore laid off equal to 200 kw. A perpendicular line is erected through D. The wattless component 529 kv-a. has not been changed. It is therefore laid off at DE, equal to BC. The resultant total load on the system is AE which is found by measurement to be 959 kv-a. The power factor of the system is

$$\frac{AD}{AE} = \frac{800}{959} = 0.834, \text{ or } 83.4 \text{ per cent.}$$

It is thus seen that a synchronous motor added to the system, even though its entire output is used mechanically, has a corrective effect on the system power factor.

Example No. 3. What is the effect of adding a synchronous motor having 250 hp. load and operating at 80 per cent leading power factor.

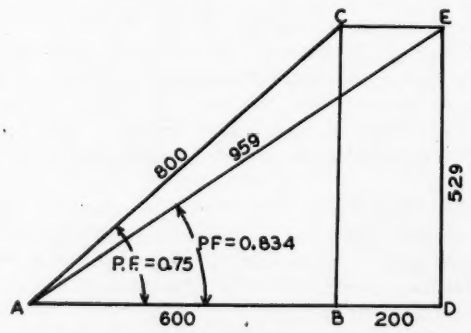


Fig. 6. Vector diagram for solving power factor correction problems

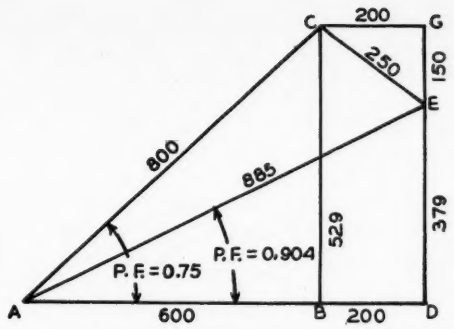


Fig. 7. Vector diagram for power factor correction problem

$$\text{Motor input for mechanical work} = \frac{250 \times 0.746}{0.93} = 200 \text{ kw.}$$

$$\text{Total input to motor} = \frac{200}{0.8} = 250 \text{ kv-a.}$$

The power component, 200 kw., is laid off as BD in Fig. 7 as a direct addition to the energy component of the system. The total motor input of 250 kv-a. is marked off from C on the vertical line DG.

$$\frac{CG}{CE} = 0.8 = \text{power factor of the sync. motor}$$

The resultant total load on the system is AE which is found by measurement to be 885 kv-a. The power factor of the system is

$$\frac{AD}{AE} = \frac{800}{885} = 0.904, \text{ or } 90.4 \text{ per cent}$$

The wattless current in the synchronous motor is 150 kv-a. This leading current is opposite in sense to the 529 kv-a. lagging current in the system. The resultant lagging current in the system after adding the synchronous motor is 379 kv-a. In this case a part of the power factor correction results from the leading wattless current introduced by the synchronous motor but a part of the improvement in power factor also results from the addition of mechanical load.

Operation at Constant Power Factor

It has been previously shown that if excitation is constant the power factor of a synchronous motor varies as the load varies. At partial loads there is generally a greater flow of leading current than at full load. In the majority of cases this variation in the amount of wattless current is not objectionable. However, in some instances it is preferable that the synchronous motor operate with approximately uniform power factor near 100 per cent at all loads. Such operation can be quite readily obtained with synchronous motors forming part of a motor-generator set. The principal connections for this scheme are shown in Fig. 8. A separate exciter is provided for the field of the synchronous motor. The shunt field of this exciter is relatively weak. When there is no load on the set, the exciter voltage is a minimum and the synchronous motor fields are excited only enough to cause approximately 100 per cent power factor at no-load. The series field of the exciter is connected across a shunt or otherwise arranged so that the current flow therein is proportional to the load of the direct-current generator. The effect of this series field on the exciter is to increase the exciter voltage, hence increase the field strength of the synchronous motor. By proper proportioning, this increase in field excitation with increase in load can be made such that the power factor of the motor remains substantially the same at all loads.

The increase of field excitation of the synchronous motor with increase of load gives to the motor increased pull-out torque when the need thereof exists, i.e., when the load increases. Sometimes it has the further effect of maintaining the alternating voltage in the face of the increase in motor load, thereby enabling full torque to be maintained. This feature may be important when the motor is connected to a line which might otherwise suffer severe voltage drop under load.

Cognizance should be taken of the fact that the synchronous motor has a high power factor only when properly excited. It is quite possible, through careless-

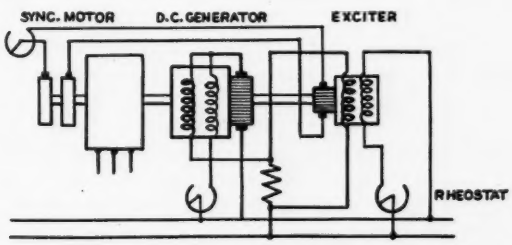


Fig. 8. Connection for motor generator set to cause the synchronous motor to operate at constant power factor

ness, to obtain a poorer power factor with the synchronous motor than that normal to the induction motor. Some attention to the excitation is essential.

Table I. Comparison of synchronous motor rated at 100 per cent and at 80 per cent power factor

	Values in the table show the relation of a motor rated on 80 per cent power factor basis to	
	Same frame rated on 100 per cent power factor basis	Smaller frame rated on 100 per cent power factor basis but developing same horsepower
Horsepower rating....	30% lower	Same
Efficiency	2 to 3% lower	1.5 to 2.5% lower
Power for excitation..	60 to 60% higher	70 to 90% higher
Starting inrush:		
Total kv-a.	Same	40 to 50% higher
kv-a. per hp.....	40 to 50% higher	40 to 50% higher
Starting and pull-in torque:		
Total lb. ft.....	Same	40 to 50% higher
Lb. ft. per hp.....	40 to 50% higher	40 to 50% higher
Pull-out torque:		
Total lb. ft.....	50 to 60% higher	110 to 140% higher
Lb. ft. per hp.....110	to 140% higher	110 to 140% higher
Weight	2 to 3% higher	10 to 50% higher

Increasing Utilization of color illumination in paintings and architectural decoration may be regarded as an outstanding contribution in the field of the art of lighting. Further advancement is probably coming when through color illumination in the home or the office one may obtain "mood conditioning" which may be varied to suit our disposition of the moment.

Seals *against* Fluid Pressure

Part II—Materials used as principal constituents of packing and gaskets and their characteristics which suit them for the purpose.

ALTHOUGH many of the materials used for packing are the same as those used for gaskets, a distinct difference in requirements exists. The term packing as referred to here has reference to materials used to prevent leakage past rods, pistons or shafts that must, because of their functions, move with respect to the surrounding element. It is usual to contain such material within a stuffing box fitted with a gland to retain the packing in place and at a desired pressure against the rod. It will be recognized that it must be plastic in order that it will, under pressure of the gland, completely fill all the space within the stuffing box; it must have sufficient resilience to keep the seal tight even when the rod is moved slightly radially; it must offer as little as possible resistance to the functional movement of the rod; it should withstand the wear against the rod to which it is exposed for as long a period as possible; it must endure the temperature to which the rod and gland are exposed without deterioration or change in size that will either bind the rod or cause a leak; it must not attack chemically the rod or stuffing box material; it must resist chemical attack by or solvency in the fluid contained.

Gaskets are referred to here as materials, usually in thin sheets, placed between two flat or curved surfaces for the purpose of preventing leaks between the surfaces that are tightly bolted together. This is accomplished by filling all the pores in the surfaces. To fulfill their functions properly, gasket materials must be resilient, plastic or machinable to a smooth surface, strong enough to withstand the pressure to which it is subjected, able to withstand the working temperature without deterioration, resistant to chemical action and solvency of fluid contained, electrically neutral under working conditions so that electrolysis will not be set up. Gaskets are not subject to wear as is packing so lubrication is not a factor.

In nearly all applications of packing and gaskets the requirements are such that no one material fulfills the purpose completely so manufacturers have resorted to designing products out of two or more materials to fit specific purposes.

Before discussing the various designs of packings and gaskets, which will be done in another article of this series, a consideration of the qualities of the different materials used for this purpose in power plants will help to an understanding of the entire subject. These are considered in alphabetical order so that they will be most easily referred to as the specifications and designs of mechanical packings and gasket materials are discussed in later issues.

Materials and Their Characteristics

Aluminum is a metallic element that may be cast or drawn. Cast or annealed aluminum breaks at 11,000 to 13,000 lb. per sq. in., when hardened, the strength is 22,000-28,000 lb. per sq. in. Aluminum ranks as a soft metal, hardness about half that of copper. Ductility and malleability of aluminum are very high, it may be drawn into a fine wire or beaten into a thin leaf. Thermal expansion is 2½ times that of steel and 1½ times that of copper. A thin film of oxide normally forms on the surface and protects the metal from further oxidation. Aluminum dissolves very slowly in distilled or soft waters. Hard fresh waters and sea water cause rapid local corrosion of commercial aluminum unless air is entirely excluded. Damp air merely causes roughening of surface. In the absence of water, aluminum is not attacked by the fixed alkalis, but it dissolves in their caustic solutions to form aluminates, hydrogen being evolved and solutions of sodium and potassium carbonate rapidly attack the metal but silicate of soda solutions do not. Ammonium hydrate attacks aluminum to some extent, ammonium carbonate has no chemical effect on aluminum. Almost all acids will attack aluminum readily. Annealing is effected rapidly at 662 to 752 deg. F. Aluminum may be hammer welded at 1067 deg. F. It is used in the manufacture of packings and gaskets to give structural strength to weak, resilient materials, also for metallic rod and shaft packings and piston rings.

Asbestos is the name applied to a group of minerals possessing crystalline fibrous structure which can be spun or felted. This material is incombustible and its spinning qualities make it valuable for packings and gaskets. For steam and pump packings, asbestos yarns are impregnated with graphite and suitable greases, for gaskets asbestos cloth is impregnated with rubber,

thus giving strength to the sheet, it is also used in the felted condition in the design of metallic gaskets. Asbestos is not a distinct mineral, as the term may be applied to anthophyllite, amphibole or serpentine. The first is a magnesium-iron silicate of little commercial importance. Amphiboles include a group of five types having fibrous structure, the chemical constituents being calcium-magnesium silicate, iron-calcium-magnesium silicate and soda-iron silicate. Serpentine is a hydrous silicate of magnesia and occurs in two forms which constitute the bulk of commercial asbestos probably because of their long silky fibers.

Asphalt is a semi-solid, sticky residue formed either naturally or through distillation of certain petroleums. It melts upon application of heat and consists of a mixture of hydrocarbons and thin derivatives. As a sealing material asphalt is used principally with fibrous materials like jute for calking purposes in such places as wooden tanks, cast-iron bell and spigot piping and tile piping. It is also used for impregnating fibrous gaskets for use where temperatures are low. It is acid proof but softens in mineral oils.

Babbit metal is a typical anti-friction alloy 25 parts tin, 2 parts antimony and 0.5 part copper. It is used in metallic packings.

Brass is an alloy of copper and zinc. It may be malleable or non-malleable, that containing 55 per cent or more of copper being malleable. The most widely used brass has 70 per cent copper. It has a wide range of physical properties by varying composition. It is used in metallic packings and as strengthening material for gaskets.

Bronze is an alloy of copper and tin; more fusible than copper and better suited for castings, it is harder and less malleable. Bronze is improved when fluxed with phosphorus, resulting in phosphor bronze, 1 per cent phosphorus down to trace.

Cardboard is made up of several sheets of paper pasted together to any desired thickness, 1/64 to 1/16 in. paper fibers. It is used as gaskets in some emergency cases to contain water or low temperature gases.

Copper, used extensively in the manufacture of packing and gaskets, is a metallic element that is ductile and malleable, melts at 1981 deg. F., is insoluble in water but is dissoluble in nitric acid. Copper oxidizes on the surface when exposed to atmospheric conditions but this coating of oxide acts as a protection against further oxidation and makes it a valuable material for making seals. It is used with fibers and impregnating compounds of all kinds to give wearing qualities and strength to packings. Sheet packing requiring unusual strength is frequently reinforced with copper wire netting and copper gaskets for special purposes are frequently made of two sheets of copper with a filling of asbestos to give it resilience. Such gaskets are commonly used on cylinder heads of internal combustion engines. Cork filled copper gaskets are also designed for specific purposes.

Cork is the outer layer of the bark of an evergreen oak. Its compressibility, elasticity and practical imperviousness to air and water fit it for use as stoppers for bottles and bungs, but in ground form and cemented together with plastic material it is sometimes used as a gasket material, usually metallic encased.

Cotton, secured from the cotton plant and woven into fabric is extensively used in the manufacture of packing and gaskets. Although seldom used alone except as an expedient in packing a water valve stem or pump, cotton fabric forms the body of most fiber packings giving them strength and form as well as wearing qualities. For certain purposes the fabric is impregnated with and molded in rubber, in other cases graphite and grease saturated cotton strings are used for stem packing. Cotton yarns and fabrics have a degree of resilience which is highly desirable.

Canvas, originally made from hemp fiber, is a hard woven cloth now commonly made from flax, hemp, tow, jute and cotton or a mixture of these. All canvas is essentially of double warp and intended to withstand some pressure or rough usage. For packing products, canvas is used in the same way as cotton fabrics, to give strength and form to the impregnating materials.

Duck is a plain fabric made originally from tow or flax yarns. This cloth is lighter in weight than canvas, differing in that it is single in warp and weft. It is used in the packing industry in the same manner as cotton or canvas.

Felt is a form of wool formed by matting the fibers to uniform thickness but without weaving and consequently has little strength. It will absorb and hold a large amount of oil and is used extensively in stuffing boxes where lubrication is essential. As made up, such packings are resilient.

Fiber board as used for gaskets is made up in sheet form from woodstock and has many uses where temperatures are low and seals against water or oil are required.

Flax fiber is obtained from the flax plant and is one of the strongest vegetable fibers used in industry. For packing purposes, because of its nonscoring qualities, it is used in the yarn or braided form for stuffing boxes, and as linen fabric to strengthen rubber packing. Isolated flax fibers twist clockwise while drying in a warm room, distinguishing them from hemp and jute which twist counter clockwise.

Graphite in flake form is commonly used as a lubricant for all kinds of rod packings and, in many cases, on sheet packing to prevent adherence of the gasket to the metal surfaces. It is practically pure carbon, little affected by any liquids and with some kind of carrier such as oil or water is extremely penetrating.

Hemp, as used for sealing purposes, is the fibrous yarn secured from the bark of the plant of that common name. These fibers are long and rather coarse but serve well with tar or asphalt for calking purposes.

Iron serves many purposes in the manufacture of packings and gaskets. Although possessing practically no resilience, cast-iron segments carefully designed and machined and held in place by springs constitute the working parts of several metallic packing designs now available. It is also used in ring form for gasket purposes and is commonly used for piston rings in all kinds of engines and pumps. Its physical and chemical qualifications are too well known to require enumeration here.

Jute is the fiber of corchorus species, a plant of the East Indies and South America, used largely for gunny sacks. As a packing material it is used principally for calking purposes.

Lead is used extensively in the design of metallic

and semi-metallic packings. It is one of the softest of metals, can readily be molded and offers little resistance as a bearing metal. As it melts at 620 deg. F. it cannot be used at the extremely high steam or oil temperatures that are sometimes encountered in industry. It is insoluble in water and oil but is attacked by nitric acid. Lead has almost no resilience and little strength as compared to other metals.

Leather is used extensively in making seals against water pressure, both a rod packing and especially for cup leathers on pistons. The very best leather is used for this purpose as it must withstand wear under rather severe conditions. Leather is fibrous, tough, resilient, can be formed into desirable shapes, deteriorates very little in water but in some other liquids will lose its shape and deteriorate rapidly. Leather, like all fibrous materials, will not endure high temperatures. The tanning process used has much to do with the quality of leather packings and rawhide is preferred in many cases.

Linen fabric is used extensively in the packing industry to give strength and wearing qualities to the packing, the bulk of which is made of rubber. It is made of flax fiber which is noted for its strength and wearing qualities.

Mica is used in some packings as a lubricant. For this purpose it must be ground to a powdered form. It is a native hydrous silicate, incombustible and remains unaffected by high temperatures.

Monel metal is a native alloy consisting of 67 per cent nickel, 28 per cent copper and 5 per cent manganese and iron. Its melting temperature is 2120 deg. F. and its high resistance to corrosion makes it valuable material in the construction of metallic gaskets for special purposes.

Nickel has been used to a limited extent for gaskets, its value being its high melting temperature of 2645 deg. F. and the fact that it is insoluble in water, dilute acids and alkalis.

Oils of the lubricating variety are used extensively in packings of the metallic and fibrous type where the rods are run dry. They must be able to withstand the working temperature of the rod without deterioration.

Paper of the ordinary writing, book or wrapping type has been used many times for gaskets where temperatures and pressures are low but usually as an expedient when better materials were not available. It has little strength, very little resilience, but when softened with water, oil, or shellac it does fill the pores in rough surfaces of flange faces.

Papier-Mache, a specially molded fibrous board, has been used successfully for gaskets under specific conditions. This material is waterproof, resilient, has considerable strength and is readily cut to any gasket shape.

Pastes and **Plastics** applied to flange faces are frequently used in place of gaskets. The formulas, however, are in most cases trade secrets so that little can be said about the qualities of their ingredients.

Rubber is by far the most important and generally used material entering into the design and manufacture of packings and gaskets. Its qualifications are numerous, and these may be varied to a great extent by manufacturing processes and incorporating other materials in the design so as to give an almost infinite variety of applications. Ordinary rubber is the most elastic solid material used in industry yet by treatment it can be made into an amorphous mass devoid of elasticity. Rubber is soluble in turpentine, naphtha, benzine, carbon tetrachloride and carbon disulphide, it is not soluble in water but is softened by such substances as naphthalene, paraffin oil, pine oil, tar, pitch, resin and gums. For this reason oils should not be used for lubricating packings made of rubber. Graphite, ground mica or soapstone are lubricants suitable for this purpose. Rubber packings must not be subjected to high temperatures in service or they will vulcanize and lose their elasticity or may take fire at some high steam temperatures now used in industry. For packing purposes the strength of rubber is increased by reinforcing it with fabric such as duck, canvas or linen cloth in some cases even wire netting is employed. Rubber is readily moulded into desirable shapes but it is not machinable except when vulcanized.

Soapstone, also known as talcum, chemically is a hydrous magnesium silicate and has a soft, greasy touch. In the pulverized form it is used as a packing lubricant.

Steel takes it place among packing materials because of its strength, resilience when in the form of springs or corrugations, resistance to wear, ease of casting, drawing, pressing and machining, resistance to deterioration under high temperatures and its ability to form a low friction bearing surface. It is widely used in metallic packings and for piston rings, also frequently does service as a ring gasket between specially designed flanges; in corrugated form or other spring design together with asbestos, steel gaskets are in common use with standard flanges. One of the disadvantages of steel is its tendency to rust, this, however, is now being overcome by the use of alloys.

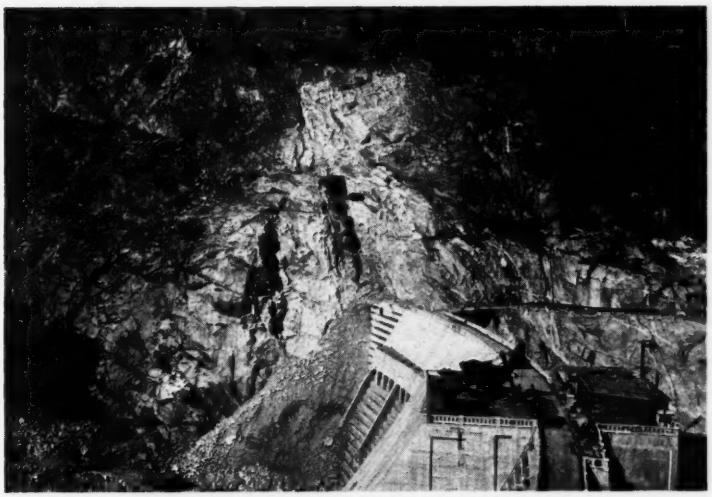
Tallow is the fat from the abdominal cavity of sheep or cattle and is used extensively as a lubricant for wick packing in low pressure steam engine packing glands. Its melting temperature is at from 113 to 122 deg. F. It is not soluble in water but is in alcohol or ether.

Tar derived from coal is a thick, black liquid that is practically insoluble in water and for this reason has been used extensively for calking purposes, particularly in wooden tanks and vessels. When heated tar becomes a penetrating fluid and is usually applied after the crack has been filled with jute or hemp yarn. Tar paper, that is paper impregnated with tar, has on occasion been used as gaskets for cold water piping.

Wood, as an expedient, has been frequently used for gaskets for handling water, oil and low pressure steam. For this purpose soft, resilient, homogeneous wood serves best. Its disadvantages are: lack of strength, irregularity in structure, deteriorates rapidly and crushes under pressure, particularly when used in thin plies. Wood fiber in the form of paper, impregnated with tar or asphalt, forms servicable gasket material for some purposes.

Wool is used extensively for rod packings in the form of felt which has resilience and is an excellent retainer of lubricating oil or grease.

(To be continued.)



View of O'Shaughnessy Dam showing preliminary work on new addition.

MORE POWER *from O'Shaughnessy Dam*

By C. W. GEIGER

THE HETCH HETCHY is the principal impounding reservoir of San Francisco's water supply and hydroelectric power system. This reservoir was formed by the construction of the O'Shaughnessy Dam in 1923 and as it now stands provides a storage capacity of 67 billion gallons with 220 ft. depth of water at the dam.

For ordinary municipal and domestic purposes the city's reservoir development here and elsewhere is ample for many years to come. Eleven years' experience in the operation of the 80,000 kw. hydroelectric power development at Hetch Hetchy under more favorable conditions for disposal of power than were at first anticipated, has demonstrated the economic value of greater storage capacity for the purpose of additional hydroelectric generation.

For this reason the second and final section of the O'Shaughnessy Dam is now being built. It will increase the capacity of Hetch Hetchy reservoir to 117 billion gallons with 306 feet maximum depth.

The enlargement of the dam is being accomplished by building an addition against the downstream side of the part of the present dam above elevation 3,500 to increase the thickness, and continuing the addition to a crest elevation of 85.5 feet above the present crest. The final height will be 312 ft. above stream bed and 430 ft. above the lowest point in the foundation, the maximum thickness at the base remaining 308 ft. The addition requires 268,000 cu. yd. of concrete.

The most interesting problem in adding the new section is that of making the present dam and the addition act together as a homogeneous structure. The concrete is now 13 to 16 yr. old, and in that time has undergone practically all the shrinkage that normally occurs in the process of setting and cooling, as well as other physical changes. Furthermore, the addition will be constructed while the old concrete is under stress due to the head of water in the reservoir. If the addition were built by simply pouring new concrete against the old, then on completion the water rising to the new flow line of the reservoir would cause the old part of the dam to become greatly overloaded, because of the superior characteristics of the old concrete resulting from its age, and because of the old concrete being already stressed by external load during construction while little or none of this load could be transmitted to the new concrete.

It is planned to bring the new concrete to approximately the condition of the old within the construction period by two expedients:

1. By making concrete that will initially be of a somewhat higher grade than the existing concrete when the latter was poured.

2. By artificial cooling of the concrete. This artificial cooling requires the use of a refrigerating plant and a system of piping for the circulation of cooling water through the mass of the dam. By this means reduction in temperature that would normally require

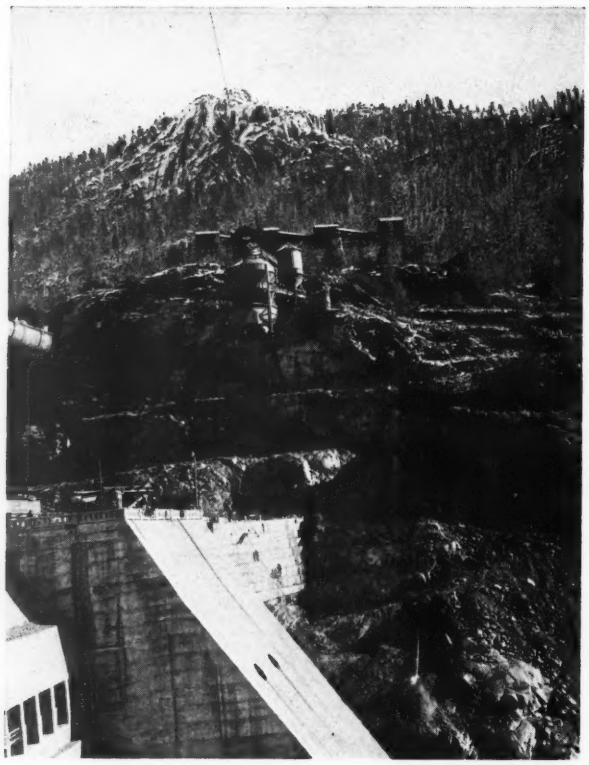


Fig. 2. Concrete mixing plant on hillside above dam

years in such a mass of concrete will be caused to occur within the space of a few months.

No Sub Stream Work Necessary on New Project

The design for a dam of the height now being constructed was made prior to construction of the present dam and the base portion of the existing dam, below stream bed level (elevation 3,500 ft.) was built to the full size required for the ultimate dam, to make work below the stream bed level unnecessary in the present construction. Above elevation 3,500 ft. the dam is of only normal dimensions for its present height, except for a block containing six of the outlet conduits, which is of full thickness for the ultimate dam. Thus there is a shelf 80 feet wide on the downstream side at elevation 3,500 to serve as foundation for the present addition.

The downstream side of the dam above the level of the shelf is finished in steps 5 feet high, intended to assist in bonding the present addition to the existing structure. Copper water-stops were inserted in the crest surface, near the upstream face, half imbedded in the concrete, the other half, now folded back into a temporary wooden box, to be unfolded and imbedded in the concrete of the present addition, to insure water tightness along the joint. The spillway consists of 18 siphons, each 10 ft. long and 4 ft. high at the top. A similar water-stop surrounds each siphon, to seal the joint between the old concrete and the concrete that will plug the siphon. The shelf, the steps and the water stops are all the provisions made in the original construction for later work, except as to a few minor details. Six radial vertical contraction joints divide the dam into 7 blocks averaging about 90 ft. in length, measuring along the upstream face. The joints have never been grouted, as the design did not contemplate the development of arch action.

The contact surfaces between old and new concrete are being roughened to assist the bonding, and in addition, where stresses of considerable magnitude cross joints in directions that are not nearly normal to the joint surfaces, notches are being cut into the old concrete to provide for transmission of stress in compression and eliminate high shearing stress along the joint. For further mechanical bond between old and new concrete, steel anchor bars will be set in the existing downstream face and their projecting ends will be imbedded in the new concrete. For this purpose holes 2¼ in. in diameter are being drilled 5 ft. into the concrete, at intervals of 5 ft. vertically and 2 ft. 6 in. horizontally. The bars will be 1¾ in. square reinforcing steel, about 16 feet long, grouted into the holes and projecting about 10 feet into the new concrete work.

The siphon spillway of the present dam will be replaced by a channel spillway at the south end of the dam, with a weir crest 195 ft. long in three sections, each section having a radial gate 10 ft. in height, with provisions for automatic operation. Ten of the siphons will be plugged with concrete during the earlier part of the construction period, the other eight, supplemented by the outlet conduits, being sufficient to handle the river flow during construction. The eight will be extended, first by means of flumes and then through the new concrete, and left open until the new spillway is ready for use. The concrete filling the siphons will also be subjected to cooling and grouting.

The bulk of the concrete placed on the downstream side of the existing dam will not be poured directly against the present downstream face, but slots having

Fig. 3. View down stepped back of dam showing drill carriage ready for anchor holes

an average thickness of about 5 feet will be left open along the joint between the new concrete and the old, only narrow ribs being poured against the old concrete to support the weight of the new. The filling of the slots with concrete will lag sufficiently behind the pouring of the main bulk to permit the greater part of the shrinkage of the latter to occur before the slot is filled. The subsequent shrinkage of the concrete placed in the slot will be a very small matter, and practically negligible. However, provision will be made for grouting whatever cracks may develop between the two masses of concrete due to this shrinkage.

The pipes for cooling the new concrete will be arranged in horizontal layers or coils, with 1 in. pipes spaced 5.5 ft. apart in each horizontal layer, and 5 ft. vertical distance between layers. Connections will be so arranged that water from the reservoir may be circulated through any coil without artificial cooling while the concrete temperature is considerably above that of the reservoir water, and until the difference in temperature between the water and the concrete adjacent to the coil is no longer sufficient to maintain the desired rate of cooling, after which direct use of the reservoir water in the coil will be discontinued and the water taken from the refrigerating plant to complete the cooling process. Two independent systems of supply and return header pipes, graduating from 8 to 2 in. diameter, are required, one for direct circulation of reservoir water, the other for refrigerated water, and each coil will be connected through valves to both header systems. This makes it possible to circulate water from the reservoir through recently poured blocks of the dam at the same time that refrigerated water is being used to complete the cooling of older concrete. Arrangements will be made for observing temperatures in the concrete mass, and the rate of cooling will be controlled by adjusting the rate of flow of the water so as to cool as rapidly as possible while avoiding excessive differences of temperature between the concrete immediately adjacent to the cooling water pipe and that more remote from the pipe, which might set up permanent internal stresses within the mass; and also avoiding subjecting recently poured concrete to such a low temperature as would unduly retard its setting.

Engineers Honor Two Veterans

AT ITS RECENT CONVENTION, held at Hot Springs, Va., in May, the Refrigerating Machinery Association honored two of its oldest members, men long identified with the refrigerating industry. These two members, Ezra Frick, President of Frick Co., Inc., Waynesboro, Pa., and Henry Vogt, President of Henry Vogt Machine Co., Louisville, Ky., were made honorary members.

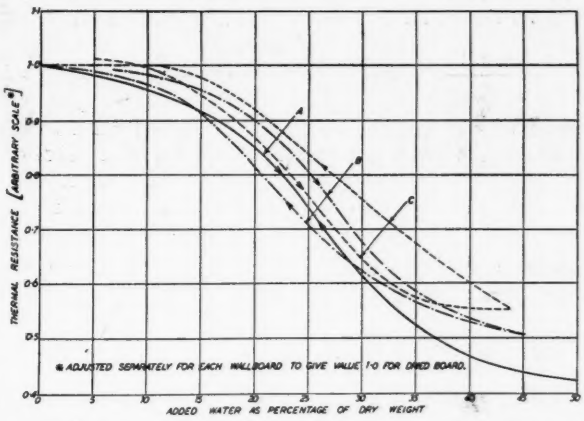
Mr. Vogt has been identified with the Association for more than 40 yr. In 1880 he opened a small machine shop and in 1885 added a boiler shop and manufacturing facilities, having developed the Vogt absorption machine. In 1911 drop forged steel valves and fittings were added. The company has become a decided factor in the manufacture of equipment for oil refineries, power plants and refrigerating machine products.

Thermal Resistance of Wall Board

ALTHOUGH it is well known that the thermal resistance of a porous material depends upon its moisture content, little attempt has been made to take account of this factor until an investigation was undertaken at the Building Research Station in England and reported by H. E. Beckett in the April issue of the Journal of the Institution of Heating and Ventilating Engineers.

Readings were continued with increasing moisture contents until the amount of water present made accurate testing impossible. The cycle was then retraced and finally the board was oven-dried at a temperature of 212 deg. F.

There are differences in the slopes of the curves and very marked differences in the behavior of the various boards as they are dried. Three typical curves are shown by the illustration. With board A the


THERMAL RESISTANCE (ARBITRARY SCALE)*
ADDED WATER AS PERCENTAGE OF DRY WEIGHT
* ADJUSTED SEPARATELY FOR EACH WALLBOARD TO GIVE VALUE 1·0 FOR DRIED BOARD.
A
B
C

Variation of the thermal resistance of three wall board specimens with moisture content

curves for wetting and for drying are identical. With boards B and C, on the other hand, the curve for drying is considerably displaced from that for wetting, being below in the one case and above in the other. These differences appear to be connected with the water repellent treatments to which most of these wallboards are subjected in manufacture.

It is significant that board A absorbs some twelve times as much water as any other board tested, when placed in contact with water. The relatively high values at which the curves flatten out (the thermal resistance of ½ in. of pure water, on the same scale, is somewhat less than 0.1) shows that the individual fibres, even when thoroughly wetted, retain a considerable insulating power.

With regard to the changes in insulating value which are to be expected in practice, it may be mentioned that when exposed to saturated moist air for long periods most wall-boards increase in weight by about 10 per cent. Reference to the curves shows that the decrease in thermal resistance caused by this change is not serious. A large decrease is only likely to occur where a wall-board is persistently wetted by condensation, leakage or infiltration.

As One Engineer to Another—

In their last conference on engineering problems, the Chief and G. F. calculate fuel costs and the amount of water that accumulates in compressed air receivers.

By G. F. WETZEL

"WOW, G. F.," began the Chief as I sat down in my favorite chair in his office, "I would like to apply one of the problems we went over sometime ago and see what the fuel cost for 1000 lb. steam would be with an efficiency of 80 per cent. I will assume a feedwater temperature of 150 deg. F. and a steam pressure of 100 lb. ga. I know the equation to use," and he reached for his note book. "Here it is: $E = \frac{W\,(H_1 - q_2)}{H_f}$ where E is efficiency, W is weight of water evaporated per unit of fuel, H_1 is total heat of steam at the given pressure, H_f is the calorific value of the fuel, q_2 is heat of the liquid of the feedwater.

"That is correct, Chief," I told him. "Use No. 6 oil with 150,000 B.t.u. per gal. at 4 cents delivered in Chicago. And if you want your weight of steam from and at 212, then $H_1 - q_2$ will be 970.4, and this will save you the trouble of looking up your values at 115 abs. and also the factor of evaporation."

He then went ahead with his calculations.

$$W = \frac{E\,H_f}{H_1 - q_2} = \frac{0.80 \times 150{,}000}{970.4} = \text{wt. of steam}$$

$$\text{Cost per 1000 lb.} = 1000\,W \times 4$$

$$= \frac{1000 \times 4 \times 970.4}{0.80 \times 150{,}000}$$

$$= 32.3\text{c}$$

"Nicely done, Chief," I complimented him. "And now to amplify what we went over when we discussed some of the laws of vapor and air, there was a problem we didn't get to,—and I want you to do it. You know that when air is compressed, water must be drained out of receiver and pipes. Where does the water come from, and why? Assume that the pressure is 100 lb. ga., or 115 (approximately) lb. abs.; that it leaves the compressor at a temperature of 120 deg. F.; that the supply air is at 70 deg. F. and 50 per cent relative humidity. If you will refer to your notes, you will find that this air has 13.52 cu. ft. per lb."

"I suppose the way to go at it," the Chief was thinking out loud, "will be to find the amount of vapor mixed with the air at atmospheric pressure and 70 deg. F., and then check the conditions at the high pressure. From the steam tables, I see that the weight per cubic foot of saturated vapor at 70 deg. F. is 0.001148 lb., which would be cut in half at 50 per cent relative humidity, or 0.000574 lb. per cu. ft. Therefore the weight of vapor per pound of air will be the number of cubic feet per pound of air times the weight of one cubic foot of vapor, since they occupy the same volume at the same time: 13.52 × 0.000574 or 0.00776 lb. At 115 lb., the specific volume can be found from the gas law, PV/T = 0.3703

$$\frac{115 \times V}{460 + 120} = 0.3703$$

$$V = \frac{0.3703 \times 580}{115} = 1.868$$

"Weight of vapor will be 0.00492 lb. per cu. ft. at 120 deg. F. (from steam tables) which would give 0.00919 lb. for the weight of vapor contained in a pound of air under 115 lb. pressure. But wait a minute, G.F., a pound of high pressure air at 120 deg. F. will hold more water vapor than a pound of atmospheric air we started with under the conditions you gave, so there will be no condensation of moisture."

"That is true, Chief, but if the compressor discharges into a tank where the pressure is the same but the average temperature is that of the room, 70 deg. F., what happens," I questioned.

"The vapor pressure, and weight per cubic foot would have to correspond to 70 deg. F., and then from the number of cubic feet per pound of air at 115 lb. abs. and the weight of saturated vapor per cubic foot, the weight of vapor that the air could hold could be figured. From the steam tables, we found that the weight of saturated vapor per cu. ft. at 70 deg. F. is 0.001148 lb. and we must find the volume per pound of air at 115 lb. abs. and a temperature of 70 deg. F. which we can do by taking the ratio of the absolute temperatures times the volume we found for 120 deg. F., or 530/580 × 1.868 or 1.707 cu. ft. per lb. Now, the weight of moisture which the air in the tank can hold is 1.707 × 0.001148 lb. or 0.001960 lb. per pound of air. This means then, that each 1000 lb. of air would have 1000 × (0.00776 — 0.00196) = 5.8 lb. eliminated. (0.00776 is moisture per lb. of air at 70 deg. F., 50 per cent relative humidity, and atmospheric pressure, 0.00196 is moisture per lb. of air at 70 F. and tank pressure of 115 lb. abs.) So 5.8 lb. or almost three-quarters of a gallon of water will be squeezed out of 1000 lb. of air compressed. How'm I doin', G. F."

"That shows you haven't forgotten how to use

your steam tables, Chief. Your expression 'water squeezed out' is very apt, because that is just what happens. As long as the temperature of vapor or steam stays constant it is impossible for its pressure to rise above the saturation pressure. Therefore, no matter what happens to the pressure of the air it may be mixed with, the vapor pressure stays the same, and consequently you cannot get any more into a given space than the weight per cubic foot corresponding to the temperature for saturated vapor. On the other hand, air may be compressed at will, so you might say that the air is pushed together or made thicker, so to speak, while the vapor, being non-compressible, stays as it is, unless there is a temperature change. From this you can plainly see just why it is that when air is compressed and kept at, or brought back to its original temperature, a considerable amount of water is condensed out."

"I certainly am glad that I begin now to realize that the laws of steam and air are not so mysterious after all, and it is interesting to see how many applications there are for the information given in the steam tables. A year ago, if any one had told me that I would be able to figure out this air compressor problem and know what it was all about, I would have thought it was a pipe-dream," the Chief said, sincerely.

"I appreciate the appreciation, Chief. Now, this will be the last of our discussions for a while, because I want to give you time to digest what we have been going over, and my time will be very much occupied, so while I will give you a phone call every now and then, I won't be able to drop in on you as I have been doing. So as a final dose of something to think about, I want to leave some thoughts with you about selling your services, which I am quite sure you will find helpful.

"Suppose you were suddenly put in a position where you had to find a new place to work,—what would you do?"

The Chief looked at me with a puzzled expression, as if he was wondering what I was getting at, and then replied, "Why, I would look around and find myself another job."

"And what is a job, Chief?"

"A job is,—well, a job is where you work for a person or an organization, and get paid for it," he replied.

"Did you ever stop to think, Chief, that you and I and every man who works for anyone else at any time, are all salesmen?"

"Salesman? Me?" the Chief questioned. "What do you mean, G. F., and would you mind telling what I am supposed to be selling?"

"You certainly are a salesman, though I am sorry to have to tell you that I don't think you are a very good one, but after this talk, I hope you will be a better one, because you will realize that you are a salesman—have to be—and will know exactly what you have to sell. The best definition of a salesman that I ever heard is this: 'A salesman is a man who sells.'"

"Don't be so mysterious, G. F. Tell me what you are driving at," the Chief said impatiently.

"Nothing mysterious at all, the commodity you have for sale, and right now you are selling, is services! When you have a job, you have merely consummated an arrangement for selling your services, whereby you furnish certain services for a certain period of time, and receive a certain amount of money in payment. Holding a job is a continuous sale of services. I don't care whether you are the president of a great and wealthy corporation or a poorly paid laborer, or any one in between these extremes, all any man has to sell or dispose of is his services.

"Now to get personal, what have you got to sell? You have the practical knowledge, and the executive ability to run this plant. You also have, I hope, an understanding of the theory of steam and heat and combustion so that you can get the maximum practicable day-to-day efficiency out of your plant. You also have (or will acquire) a knowledge of the basic principles and laws of air conditioning, and refrigeration, because these are closely tied up with work of the operating engineer. You also have an up-to-date knowledge of new appliances, use of superheat, and the trend toward the use of higher pressures. But most important of all, you have the knowledge and ability to keep your employer convinced that he is making a profitable purchase of your services. In other words, you have a reserve capacity, initiative, and knowledge, above what is required merely to hold down your job, to enable you to meet developments, problems, and more responsibilities."

Small Diesels Top the Flood

(Continued from page 341.)

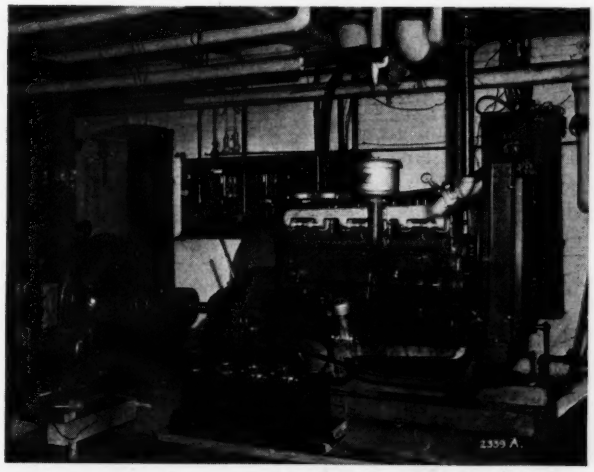


Fig. 2. This engine did emergency service in the National Insurance Co. building at Hartford following the flood and earned a permanent place there as a standby unit

a motor supplied by current from a central power plant which was forced by the high waters to suspend operations. The accompanying picture shows the Cummins engine on the job in the Municipal Water Pumping Plant at Cromwell.

When electric power could not be obtained from the inundated power plants of Hartford, a Cummins-Diesel was rapidly pressed into service to supply lights, operate the motor driven oil-burner and air conditioning outfit for the entire building in which the National Fire Insurance Co. has offices. The unit will be retained permanently in this building as stand-by equipment in case of future emergencies.

Operating Code *for* Modern Plants

Concluding sections of the power plant operating code of Hiram Walker & Sons, Inc., Peoria, Ill.

IN THE PLANT to which this code refers there are installed two 150,000 lb. per hr., 250 lb., 500 deg. F. bent tube boilers with air heaters, forced and induced draft fans, water cooled furnaces and combustion control. Feedwater is treated chemically. Electric power is generated by two 1500-kw. back pressure turbine units and exhaust steam is used in process work. The plant is tied in with the utility system on a power interchange agreement.

The operating code was compiled by the power engineer, W. F. Biggs, for the guidance of employees primarily to promote operating efficiency, fix responsibility and prevent accidents.

VII. SHUTTING DOWN BOILER

A. TAKING BOILER OUT OF SERVICE.

1. Open the air tempering valve to the pulverizer and close the air control valve. Continue operation for about 5 min.
2. Stop the raw fuel feeder.
3. Stop the pulverizer when empty. When the flame, at the burners in connetion with the pulverizer being shut down, goes out, the pulverizer may be considered empty for shutting down purposes. The operator will also notice a more metallic sound emitted from the pulverizer.
4. Stop the pulverizer fan and close the fuel air valves in the burner lines.
5. Stop the forced draft fan and close the forced draft dampers at the burner windbox and secondary air ports.
6. Stop the induced draft fan and close the induced draft damper until the draft is just sufficient to keep the furnace clear of gases.
7. Stop the preheater motor.
8. Pull burners out of their operating positions.
9. Close the main feed valve to the boiler but be sure to have at least 6 in. of water in the gage glass.
10. Shut off spray nozzles in ash pit.
11. As the steam pressure drops, close main header valve.
12. Open superheater drain valves.
13. Open drain valve between automatic and main header valve.
14. Hang "Out of Service" sign on boiler.

B. EMERGENCY SHUT DOWN.

When an emergency shut down is necessary and there is sufficient time to clear the pulverizer, proceed as follows:

1. Stop the raw fuel feeder.
2. Stop the pulverizer when a decided metallic sound is noted.
3. Stop the pulverizer fan.
4. Close the air control valve and the valves in the burner lines and open the air tempering valve.
5. Stop the forced draft fan and close the forced draft dampers at the burner windbox and secondary air ports.
6. Stop the induced draft fan and close the induced draft damper.

C. FORCED SHUT DOWN.

In case a shut down of the pulverizing equipment occurs and the pulverizer has not been run empty (caused by an electrical trip-out of some of the equipment in the electrical interlock) the equipment again should be put into service as soon as possible according to the method described under "IV. STARTING BOILER ON PULVERIZED FUEL." Operate the equipment with pulverized fuel for 15 min. Then if it is desired to discontinue operation, proceed to shut down according to "VII. A. TAKING BOILER OUT OF SERVICE."

VIII. FIRES IN EQUIPMENT

A. FIRES IN PULVERIZERS.

1. Causes of fire.
   a. Pulverizer allowed to stand partially filled with pulverized fuel while hot.
   b. Too high temperature of air to pulverizer.
   c. Fire in raw fuel bunker.
   d. Fire started in idle equipment by welding or burning operation. Equipment should always be inspected after these operations.
   e. There is some evidence that coal high in pyrites is more susceptible to ignition than other coal.
2. Handling a fire in a pulverizer shut down. The

The power plant operating code of Hiram Walker & Sons, Inc., is divided into ten sections. The first six sections, I, General instructions to boiler operators; II, Starting boiler on gas; III, Changing from gas to pulverized fuel; IV, Starting boiler on pulverized fuel; V, Loss of ignition; VI, Soot blowing, were published in the two preceding issues, on page 158 of the March issue and page 237 of the April issue.

object of all methods of dealing with this class of fires is to smother them by reducing the oxygen supply to a point where combustion will not be supported.

a. Close the air tempering valve to the pulverizer. The other valves in connection with the pulverizer are normally closed as routine operation during a shut down. Check to see they are closed.

b. Open the air-port clean-out doors one at a time and drench the interior at the air ports with the discharge from a chemical fire extinguisher or steam. Close the clean-out doors. The operator should stay out of direct line of the clean-out openings.

c. Repeat the drenching at the air-port clean-out doors for one-half an hour at intervals of about 10 min.

d. Open the access doors carefully (taking precautions that any gas which may have generated during the period of the fire will not ignite) and drench the interior with the discharge of a fire extinguisher. When the fire has been extinguished and the fuel has been cooled below the ignition temperature and poisonous gases in pulverizer have escaped, the pulverizer should be cleaned out so that it is certain that no trace of fire remains. Air in any way should never be used for cleaning pulverized fuel equipment suspected of containing fire and the use of vacuum cleaning systems for cleaning pulverizers is hazardous at any time.

e. Inspect and clean out the pulverizer windbox, air inlet ducts, outlet pipes, pulverizer and feeder of any residual fire.

f. When certain that the pulverizer and related equipment is clear of all traces of fire, the equipment may again be put into operation according to the normal procedure.

3. Handling a fire in an operating pulverizer.

a. A fire in an operating pulverizer usually makes its presence known by an increase in the outlet fuel-air temperature that can not be accounted for by changes either in the raw fuel moisture or the air inlet temperature. Moreover, this increase in outlet temperature is sudden and of considerable magnitude, usually of the order of 100 deg. F. or more. The maximum normal outlet temperature should not exceed 160 deg. F.

b. Increase the raw fuel feed to the pulverizer to the maximum pulverizer capacity. If the pulverizer is already operating at maximum capacity, be sure that the raw fuel feed is not decreased. Special precautions should be taken to see that the raw fuel feed is not interrupted during the entire time that a fire is suspected. If the raw fuel feed should be interrupted, immediately trip out the pulverizer and feeder and close all valves connected to the pulverizer.

c. Change over from hot to cold air operation. Avoid increasing or making sudden changes in the air flow.

d. If the temperature rise of the outlet air is checked and starts to return towards normal in a few minutes, continue operation until normal outlet temperature is restored. The pulverizer capacity may then be reduced according to operating demands. However, if the pulverizer capacity is reduced, be sure that the air flow is also reduced as to keep a rich fuel air mixture in the pulverizer.

e. If the temperature rise of the outlet air is not checked and returns to normal, shut down pulverizer and proceed as in "2. Handling a fire in a pulverizer shut down."

B. Fires in Other Equipment.

1. A fire found in any other part of the pulverized fuel system, for example, between the pulverizer and burners, should be extinguished by drenching with the discharge from a chemical fire extinguisher or steam. However, any accumulation of fine dust should not be disturbed and drafts over the area on fire should be avoided. After the fire has been extinguished, the equipment should be cleaned and all the equipment in connection with the unit should be inspected carefully before the unit is again put into service.

2. A fire in the raw fuel bin should be looked upon as serious and should be handled promptly and adequately the same as a fire discovered in an operating pulverizer. Fire in bins provided with covers should be smothered if possible by piping steam into the bin. In open top bins, the fire may be extinguished by soaking the area on fire with water.

When water is used to extinguish the fire, precaution should be taken to prevent the water which runs down through the bin from flooding the pulverizer. After the fire has been extinguished, the bin should be emptied. In feeding this raw fuel to the pulverizer, special care should be taken to feed the pulverizer continuously at maximum capacity with the least possible air flow. If for any reason the feed to the pulverizer should stop, the pulverizer equipment should be shut down immediately by tripping out the pulverizer fan which controls the pulverizer and feeder through the electrical interlock.

All valves in connection with the pulverizer should be closed to prevent a draft through the pulverizer. If inspection of the pulverizer unit proves that no fire is present and the cause for the feed interruption has been removed, the unit again should be placed in service to continue the emptying of the raw fuel bin. This subsequent operating period should be observed just as carefully as the period before the interruption took place.

IX. TURBINE ROOM PROCEDURE

A. General Instruction.

1. The operating engineer coming on duty must receive a report covering all matters pertaining to the operating conditions of all apparatus from the retiring operating engineer.

2. The operating engineer must verify this report by personal inspection of all equipment.
3. The operating engineer must see that he has sufficient force on hand to operate his shift before men on previous shift are allowed to leave.
4. The operating engineer must read all meters and change charts on 11 to 7 night shift. Engineers on other shifts must read meters as specified.

B. Procedure Before Starting Turbine.

1. Notify boiler room that the turbine is going to be started.
2. Remove all bolts, tools, etc., which may have been left on or near the turbine. If any repairs have been made while the machine was down, examine position of all valves on entire unit.
3. Make a general inspection to see that machine is in proper operating condition and that steam lines are free from water.
   a. Blow out all drains.
   b. Start auxiliary oil pump, examine governer mechanism and extraction governors. See that oil is at proper pressure and flowing through all bearings and all governor mechanism functions properly. Turn on water to steam seals. Examine all steam gages and see that the exhaust valve is open. See that the stop is down on the oil relay to extraction non-return valve.
4. Open throttle quickly until the turbine turns over. Then reduce the throttle opening to the point where the shaft revolves at 100 to 200 r.p.m. When the turbine comes up to 500 r.p.m., trip and then latch up the throttle and proceed to bring the turbine up to speed. Take about 30 to 45 min. in bringing the turbine up to speed and do not leave throttle until sure the governor controls the speed.
5. Listen for rubbing of moving parts while machine is coming up to speed.

C. Procedure in Synchronizing with High Line.

1. See that turbine is up to speed and running on governor.
2. See that disconnect switches are in on board.
3. Put in current switch on oil switch and exciter panel on first floor.
4. Build up voltage on exciter to 100 v. and then throw in field switch. If the switch should fail to go in, the signal light will remain green. When the switch closes, you will have a red light.
5. Build up voltage on the machine to correspond with the line voltage which is about 457 to 470 and then throw in synchroscope switch. Regulate the speed until the synchroscope is traveling very slowly in "fast" direction and then throw in switch. If the switch goes in, it will light the red signal light instead of the green one which is always showing when the machine is idle.
6. Before paralleling, call Central Illinois Light Co. power dispatcher and report the machine being paralleled. After it is on line, call back and report the time and your name and then obtain his name and record it. The same procedure must be followed when taking a machine off the line.
7. Close drains when satisfied that the lines are free of water.
8. When the oil temperature starts to come up, put water on oil cooler and maintain a temperature around 130 to 140 deg. F.
9. After the machine is cut in on switchboard and the generator starts to warm up, put water on coils and maintain a temperature between 60 to 70 deg. C. on instruments. Calibrate the instrument each time temperature is checked.
10. Always cut out extraction mechanism until turbine is up to speed and on board. Then regulate extraction pressure by regulating pressure on auxiliary regulating valve.
11. The operating engineer is responsible for the operation of all power house equipment on his shift during the power engineer's absence.

X. STARTING WATER SOFTENER

1. Discharge sludge without water waste.
2. Open priming supply and start chemical pump.
3. See that sufficient chemical mixture is left in chemical tank.
4. Open water valve and make sure there is sufficient pressure on the raw water to deliver it to the softener.
5. Turn on steam after the water is on.
6. Run hot water from the treatment tank through the blow down to the sewer to warm up the recirculating piping.
7. Close valve in blow down to sewer after 5 min.
8. Slowly open recirculation valves from boiler. Avoid water hammer and increase flow until the normal rate is established.
9. Start blow down to sewer at proper rate.
10. Open and adjust atmosphere vent on vent condenser.

Effects of Air-Fuel Ratio

Results of Studies, made with high-speed motion pictures at the rate of 2500 frames per second, of the fuel spray and flame formation in combustion chambers of engines are given in N.A.C.A. Report No. 545, by A. M. Rothrock and C. D. Waldron. A compression ratio of 13.2 and a speed of 1500 r.p.m. were used in the studies and an optical indicator recorded the time-pressure relationship in the combustion chamber. The air-fuel ratio was varied from 10.4 to 365.

Results showed that as the air-fuel ratio was increased definite stratification of the charge occurred in the combustion chamber, even though moderate air flow exists. Results also showed that the rate of vapor diffusion was relatively slow. The start of burning relative to the fuel sprays is not affected by the air-fuel ratio, nor is the rate of flame spread greatly affected.

Results in the higher ratios showed that rate of diffusion of the gases in the combustion chamber as indicated by flame spread after the maximum pressure has been reached was relatively slow. This result in itself indicates why it is difficult to obtain a good mixture of air and fuel in the combustion chamber of a compression ignition engine.

Multiple Effect Compressors *and* Their Use

Principles, application and advantages of multiple effect refrigeration which should not be confused with duplex compressors, split suction and booster systems.

BY H. B. HOWE*

MULTIPLE EFFECT REFRIGERATION is common today and is recognized by the industry as a practical method of obtaining economical refrigeration. From the standpoint of practical application, the engineer wants to know whether multiple effect can be used in his plant and, if so, what will be accomplished and what savings can be made. In addition to emphasizing power economies, additional savings in initial plant investment, savings in maintenance expense and increased plant flexibility are made possible by its use, particularly with multiple effect compressors of the vertical, single acting, enclosed type.

There has been much confusion and a great deal of misunderstanding among engineers as to the principle involved and for clarity, it is well to outline various systems, all of which have their advantages and applications but which are distinctly different from multiple effect.

Duplex Compressors

A duplex unit is the use of two compressors, each being driven by means of one common crankshaft and prime mover. Duplex installations may utilize the multiple effect principle or split suction principle, but ordinarily it may be defined as two compressor units operating at one evaporator pressure.

Split Suction

This system is often mistaken as multiple effect. I have walked into engine rooms where this system is employed and the operating engineer was under the impression that he was using multiple effect because he was carrying two suction pressures with the one compressor. Split suction, illustrated by Fig. 2, may be defined as any compressor unit using two or more cylinders where each cylinder carries a separate suction pressure.

In a horizontal, double acting type compressor one suction pressure is carried on the crank end another suction pressure on the head end of the cylinder. This requires two separate suction pipe lines to the cylinder. On a vertical, single acting compressor one pressure is carried on one cylinder and another suction pressure on the second cylinder, each being independent of the other on the suction side. Both of these methods have been widely used. The chief objection to the use of split suction is mechanical in its nature due to unbalancing of the unit necessitating additional flywheel effect in the synchronous motor or prime mover.

Booster System

Booster systems, although termed differently, are closely allied to the two-stage compressor. This system

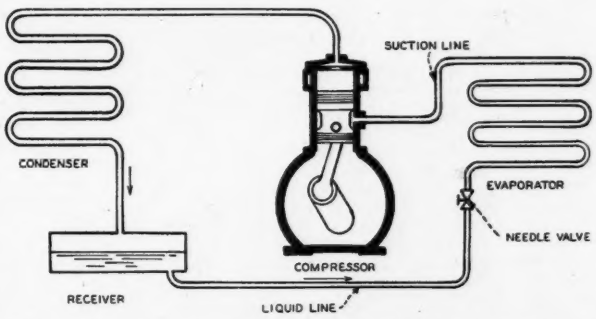


Fig. 1. Elementary single stage refrigeration cycle. Two stage compression may be substituted with slight gain in power economy but without changing the fundamental characteristic of the cycle

has been used mainly in plants requiring extremely low temperature, such as quick freezing, hardening rooms and oil refineries, such plants likewise having work requiring higher temperatures. In this system the discharge from the booster compressor, which is operating on the low suction, is piped into the suction of the unit operating on the high suction as shown by Fig. 3.

Multiple Effect

Principle of multiple effect is entirely different from those previously mentioned. A multiple effect compressor can be defined as any unit where gas of two different suction pressures is introduced into the same cylinder, one charge upon the other, the second charge compressing the previous charge up to its own pressure without mechanical effect. An elementary multiple effect system and compressor is shown by Fig. 4.

To those who are not acquainted with this principle

*Howe Ice Machine Co., Chicago, Ill.

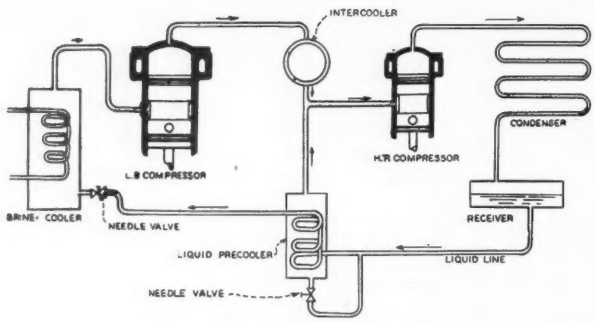


Fig. 2. If a two stage compressor is arranged so that the second stage takes gas from a second evaporator as well as the discharge of the first stage it is known as a split system. A split system may also utilize two separate compressors or separate sides of a double acting cylinder

may arise the thought that a machine to operate in this manner would be complicated from a mechanical viewpoint. Multiple effect compressors of the port type were first invented in 1905 and the principle is more than a quarter of a century old. A multiple effect compressor of the type being discussed does not contain one more moving part than a standard compressor. The only difference between the standard and multiple effect units is a longer cylinder, longer piston and one additional suction header.

Application

Applications for multiple effect are many, in fact, it may be said that any refrigerating plant regardless of whether one or more temperatures are maintained,

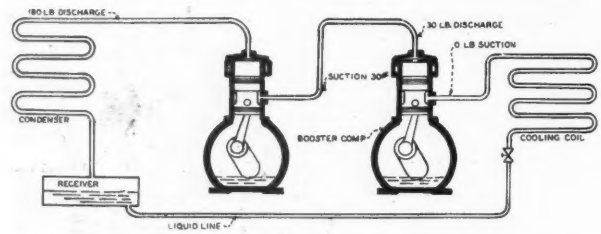


Fig. 3. The Booster system is closely allied to the two stage system but utilizes a separate compressor and is applied to very low temperature work. The main compressor may be either one or two stage

is a good job for multiple effect. In a one temperature plant the multiple effect can always be utilized for pre-cooling of the ammonia liquid, this work being done at about 35 lb. suction as shown by Fig. 5. In the average plant this work will represent at least 10 per cent of the total load. Actual savings in the use of multiple effect will depend entirely upon the nature of the work, the ratio of the suction pressures and the temperature of the condensing water. It is applicable to most industries and will show a definite saving in artificial ice making plants, cold storage, ice cream plants, milk plants, packing plants, pre-cooling and storage plants.

Savings

Savings in terms of power cost is but one phase and one upon which too much stress has been placed. Consider for a moment savings in intial investment for equipment, saving in building costs due to conserving of floor space and savings in maintenance expense. For illustration, take a combination ice and ice cream plant carrying suction pressures from 0 to 25 lb. as ordinarily used. This plant, to operate economically and to retain the necessary plant flexibility, will require two standard compressors. These two compressors will be practically the same bore and stroke as the one multiple effect unit which could handle the entire load. The saving in intial investment is considerable and one multiple effect compressor costs but a trifle more than a standard machine of the same bore and stroke. One motor is eliminated. Floor space means additional building investment and the maintenance expense of one compressor is less than two units.

Saving in power is due mainly to the basic principle of multiple effect design. We all know that increasing the suction pressure results in a corresponding increase in power per ton of refrigeration. As an illustration, let us take a plant operating at 10 and 20 lb. suction. The 10 lb. gas starts to enter the cylinder through the suction valve in the head of the piston as soon as the piston begins the down stroke. This cylinder is completely filled with 10 lb. gas as in any standard single acting machine. At the end of the suction stroke the piston encounters the high suction ports which are cast around the cylinder. The 20 lb. gas now enters the cylinder compressing the 10 lb. gas within the cylinder to the higher pressure, and when the piston starts on the compression stroke, the suction pressure has been raised from 10 to 20 lb. without the use of mechanical

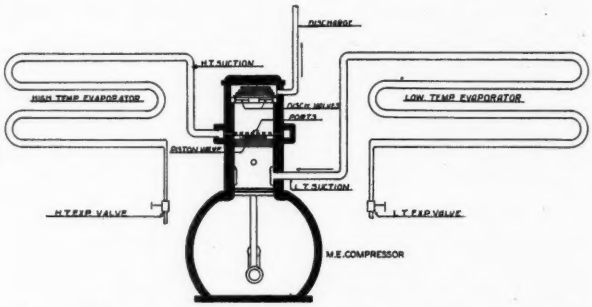


Fig. 4. The multiple effect compressor differs from all others, both suction pressures being handled by the same side of the same cylinder by means of ports and valves as shown

power. The discharge gas from the cylinder is identical in a multiple effect as in any standard machine. The resultant power per ton of refrigeration produced is slightly in excess of the power per ton of work done at 20 lb. with a standard machine.

Refrigeration capacity of the compressor is based upon the higher suction pressure. You also have the advantage of the low pressure work being done at the high suction rate of power consumed. The mechanical efficiency of the compressor and motor also enter into the calculation of power required per ton of work. In operating one multiple effect unit it is only necessary to consider the mechanical efficiency of one compressor and one motor instead of two standard machines and two motors to do the same work. It is self-evident that the over all mechanical efficiency of the one is greater than that of two units.

Many engineers are under the impression that to

utilize multiple effect there must be a definite ratio between the high and low suction work in each plant to balance the displacement of a given size compressor. This is not the case, as the operation is most flexible by means of a by-pass valve between the two suction headers. This arrangement makes it possible to admit any desired per cent of the high suction gas into the low suction side of the compressor to balance the individual plant load.

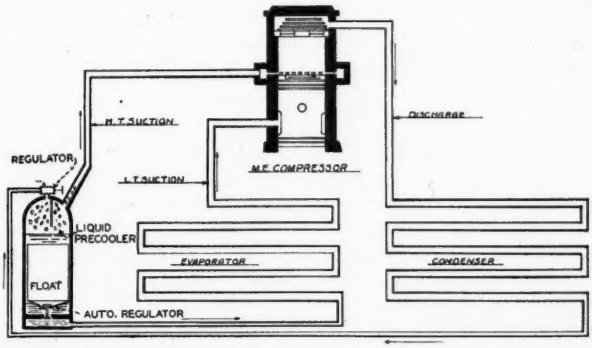


Fig. 5. Multiple effect used in this way for precooling ammonia may be expected to save 10 per cent of the total load

Statements have been made by engineers that due to the short time element when the high suction ports are open to the cylinder, it was impossible to secure a full charge of high suction gas within the cylinder. The old reliable indicator cards have disproved these statements and the majority know today that no difficulty is experienced in filling the cylinder with high suction gas by means of ample and correct port design.

To figure the refrigeration capacity of any multiple effect unit operating under a given condition is a simple procedure. This capacity is figured at the high suction pressure. In other words, the capacity of a multiple effect unit at 10 and 20 lb. suction is identical with a standard machine of the same bore and stroke operating at 20 lb. Calculate the tonnage of the low suction work and subtract it from the total tonnage of the compressor operating under the high suction. The difference between the two represents the work done with the high suction pressure.

To illustrate, a two cylinder 6½ by 6½ in. compressor operating at 300 r.p.m. with 10 and 20 lb. suction does 17.9 t. of work. This unit operating at 10 lb. as a standard machine does 12.3 t. so the work done by the high suction represents the difference between 17.9 and 12.3 or 5.6 t.

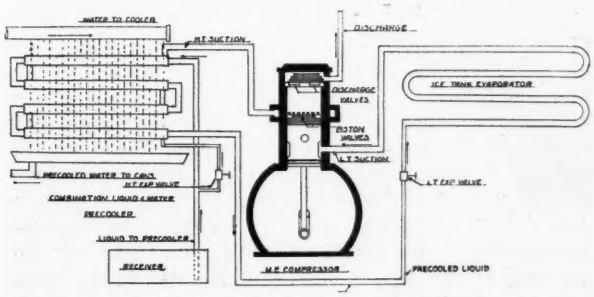


Fig. 6. Multiple effect as used in an ice plant for precooling water to the ice cans

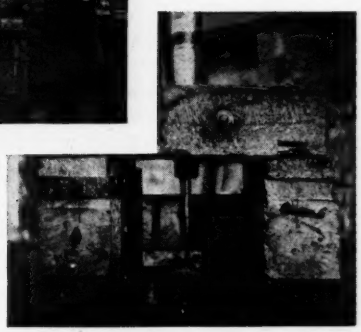
Calculating the Compressor Horsepower

Figuring the indicated horsepower is also a simple calculation by using adopted formulas of any standard machine. In the formula used for multiple effect the mean effective pressure is increased by the difference between the high and low suction, or 10, in a unit operating at 10 and 20 lb. By mean effective pressure we refer to the average pressure, during a complete revolution of the compressor. The gas pressure on the top of the piston during the down stroke is the low suction and not the high suction pressure as in a standard machine, which is the reason for the addition of the difference in suction pressures in figuring the indicated horsepower for a multiple effect unit.

The Versatile Salvage Man

Converting Odds and Ends into dollars is one of the jobs of the salvage man and the problems encountered are seldom covered by books. For this reason a recent experience of the Stores Department Salvage Division of the Union Electric Light & Power

Close up of insulation remover in operation



Operator feeding wire into the machine

Co. of St. Louis is repeated. Removal of insulation from copper wire and cable is usually accomplished by burning but this is not feasible with aluminum wire because of the low melting point of this metal. To remove the weatherproof insulation from a large quantity of aluminum wire an air operated tamper was mounted as shown by the photographs and the insulation pounded off with little labor and at low cost.

A good ventilating plant comprises not only a fan to withdraw the air but also a fan to introduce fresh air, previously cleaned and conditioned to the proper degree of humidity and temperature. In order to prevent draughts, the quantity of air introduced must be somewhat greater than the quantity withdrawn. The superfluous air passes out through various sources of leakage and thus prevents cold air entering the room.

For smokeless combustion the limit of heat release in furnaces is about as follows: For stokers 50,000 to 60,000 B.t.u. per cu. ft. per hr.; for pulverized coal 30,000 to 35,000 B.t.u.

Case Studies in Power Economics

Conducted By
ZUCE KOGAN
Kogan Industrial Service
Chicago, Illinois

Annual Fuel Costs Reduced $4000, Approximately 20 Per Cent, by Change from Coal to Oil and Gas Under Unusual Conditions.

MANY A TIME a fuel high in first cost will prove to be less expensive in ultimate cost because of the incidental expense involved around the handling, preparation, and the actual burning of the fuel. This may be true when comparing western and eastern bituminous coals, and when comparing western bituminous coal with gas and oil.

It is about such an unusual case where oil and gas proved to be the cheaper in the ultimate cost that this article will deal.

One of our clients, a large brewery, was burning in the neighborhood of 4000 t. of a No. 1 Franklin County (Ill.) egg. This coal was burned in two 300-hp. Stirling boilers equipped with very old stokers which were in great need of replacement.

Upon surveying the premises, we were convinced that, in addition to their inefficient stokers, their location was such as to prevent the economical purchase and handling of coal. The boiler plant, which was about 40 yr. old and only recently rehabilitated, was poorly laid out, especially with respect to coal delivery, and the condition was further aggravated by the fact that parcels of ground were sold off around the plant during the prohibition era, during which time the plant was absolutely idle.

It was quite obvious that because of the inconvenience of handling the coal, a fuel to be substituted should be that which could be piped.

Pulverized coal was considered, the coal to be pulverized in a space provided for that purpose near the office; thus the coal could be purchased in car load lots, the coal in powdered form to be transported by means of compressed air in pipes across the street to the boiler. This, however, was ruled out, because of additional labor required at the pulverizer, the necessity of drying, and also because of the high cost of equipment.

The next fuels to be considered were heavy oil and city gas.

In considering heavy oil, the problem of transportation was considered. If this oil were to be delivered to a tank next to the boiler room, it meant that it had to be purchased in tank wagon lots, at a cost which would have been prohibitive in spite of their present high cost of coal brought about by the peculiar circumstances of the plant. The oil would then have to be purchased at the rate of 4½ cents per gallon.

On the other hand, if this oil were to be purchased in tank car lots at only 3.75 cents, it meant the installation of a tank having a capacity of at least 10,000 gal. This would have entailed difficulties, as there were no suitable locations for it, with the exception of placing it under the railroad siding, which meant an expensive installation.

The next fuel investigated was city gas. The local utility was offering at very low cost for seven months of the year, namely, between April 1 to October 31. This rate called for a maximum of 6 cents per therm (100,000 B.t.u.) for the first two hundred therms and going down as low as 1.8 cents per therm.

Recalculating from the amount of steam consumed by this brewery during the seven month period, we found that the average cost per therm for the amount of gas they would purchase during the season would be about 2.5 cents, a cost comparing favorably with oil purchased in tank car lots.

Upon checking with the utility, we found that they had sufficient gas-line capacity to feed the brewery with gas and that it would cost about $400 to bring the gas line into the boiler room.

Gas, however, could not be purchased throughout the year because the rate, which would allow them an average rate of 2.5 cents per therm during the summer months, called for a flat charge per therm of 30 cents, and even though the brewery burned 80 per cent of the fuel during the seven-month period, this high cost during the winter months would have made the use of gas more than three times as expensive as oil, bought in tank car lots.

In view of these conditions we finally decided that the best arrangement would be city gas for seven months in the year at an average rate per therm of 2.5 cents, and oil for five months in the year at 4.5 cents per gallon, or at about 3 cents per therm.

A combination gas-oil burner was installed on one boiler only, as this boiler was of sufficient capacity and it could deliver either with gas or oil 250 per cent of its manufacturer's rating very easily.

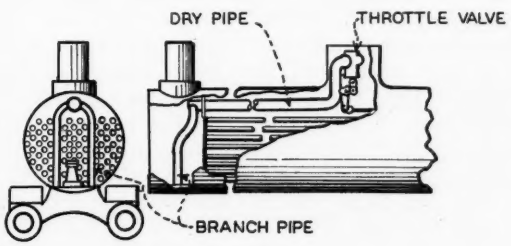
Only small changes were necessary in the furnace of the boiler after the stoker was removed and the total cost of the installation amounted to approximately $3000. After a year's run the total cost of the fuel was $17,000, consisting of $10,500 of gas and $5500 of fuel oil. If coal were burned during the same period, it would have cost them $21,000, approximately. In this case, however, the $3000 spent on the change was not so much to realize a saving of $4000, but to get away from a condition that was causing a great deal of inconvenience and a bad temper.

Readers' Conference

Corrosion of Locomotive Dry-Pipe

Two years after our locomotive was re-tubed, the fuel and water consumption jumped almost over night and the engineer had more or less trouble in hauling his regular load.

Then one day a heavy spray was noticed when a long stop had been made; in fact, it was a down pour from the stack. While the tubes had been corroding, the so-called dry-pipe had been doing likewise, until water was fairly pouring into the pipe.



The throttle was in a dry place (at the top of the steam-dome) but the dry-pipe ran (as shown) through the water above the tubes.

Lawrence, Mass. Tom Thumb.

The CO_2 Recorder

In The Above Article, on page 249 of the April issue it was explained that in order to burn natural gas most efficiently it was necessary to keep the CO_2 at just short of the theoretical limit and that the proper point could be determined by observing a CO_2 recorder and lowering the air until a point was reached at which the CO_2 value would start to drop. The article also explained that burners were now in use which would allow theoretical air supply to be used.

My experience has been that there are no burners developed which are in practical use in the firing of boilers, that are capable of being used on theoretical air supply without the accompaniment of CO and unburned hydrocarbons. I have run considerable tests on six different types of burners in as many different plants. These plants range from large central stations to large and small industrial plants. The boilers range in size from 300 to 2200 b.hp. I have yet to find one case of where CO was not present when the excess air as determined by the Orsat, was as low as 10 per cent.

Further than this the ordinary Orsat will not show unburned hydrocarbons present in the flue gases and if this is to be determined, it is necessary to make use of a Burrell Orsat or something similar. If a Burrell Orsat is used it will be determined that unburned gas is present before CO formation occurs. Since unburned gas signifies a much greater heat loss than the formation of CO, it can be readily seen that it is necessary to provide sufficient excess air so that unburned gas will not be present.

Work done by a Carnegie Tech professor some years ago indicated that unburned gas was present when the excess air was lowered beyond 30 per cent. The lower the excess air the more the unburned gas present. In one particular boiler installation the instant unburned gas became present the boiler rating was lowered considerably. All of the above tends to show the futility of relying on CO_2 measurement as a combustion guide instead of determining the excess air.

This is further borne out by my experience in Orsat work wherein it is not at all uncommon to get, within 2 min. time, samples of flue gases varying as much as 2 per cent in CO_2 and yet having the excess air remain constant. This is due to the changing analyses of the gas itself. Gas coming from different wells has a different analysis and yet the heating value may be practically identical.

The author of the above article further stated that modern furnaces were capable of standing up under theoretical excess air. This may be true of water cooled furnaces but not so of the refractory furnaces, unless a very high grade of refractory is used. As a matter of fact plants which have formerly burned coal and have changed to natural gas firing with the same furnaces, invariably find that the refractory deterioration is greater with natural gas than with coal.

Of course one reason for this is that they are operating with less excess air with gas than with coal, and perhaps with higher ratings. However water cooled walls have a bad effect on gas firing at low ratings since the furnaces are so cold and flame travel so long, because of lessened gas and air velocities, that the gas is not fully burned by the time it reaches the boiler tubes and consequently a lot of soot is formed.

To determine the excess air a good guide is the steam flow-air flow meter or a gas flow-air flow meter.

Syracuse, N. Y. Ralph R. Swain

Changes—Good or Bad?

In one factory where I was assistant chief, a large wing was heated by a vacuum system and only a fraction of a pound of steam was necessary to do the work. The plant boasted about all of the standard types of heating, viz: hot water, high and low pressure steam, hot air and vacuum. As winter set in, it was remembered that the vacuum pump, a well-known simplex model, was in need of slight repairs.

Our chief was a thorough man in some ways but short sighted in others. He ordered a spare boiler feed pump, of the duplex steam operated type, set up to take the place of the simplex. The spare unit was teed into the system, the connections that served the

simplex unit being blanked. The connections were made on Sunday and as time was limited, the simplex pump was allowed to remain near its former foundation, ready to be moved to the machine shop on the following morning. A blizzard broke at midnight, Sunday, and the heating system had to be put in commission. The vacuum system was so quick and efficient that the wing it served was delayed to the last minute.

The new installation, the duplex pump, positively refused to draw one inch of vacuum. After an hour and a half, I was sent for and I immediately replaced the new outfit with the old simplex and things began to move. The chief was anxious to see how the duplex outfit was working and was quite peeved to think that I had taken it upon myself to reinstate the invalid. The duplex had soft rubber valves and fresh piston packing, new rod packing and almost new cylinder linings so we were dumbfounded that it failed.

Having a day off, I took a trip to the pump shop which was not far distant. The superintendent showed me blueprints of both pumps and called my attention to the fact that an air pump has its clearance reduced to the minimum, while the feed pump has space to spare. That was more than 35 yr. ago.

Lawrence, Mass. TOM THUMB.

Sticking of Contactors

I HAVE had a great deal of trouble with the type of controller described by C. V. in the March issue of Power Plant Engineering. For many months after taking over the position I now hold, I could be discovered, at frequent intervals, roosting uncomfortably on the top of our washing machine, gazing disgustedly at a mechanism which had ceased to function, wondering what I could do about it, if anything. I think I can say now, however, after 6 yr. of trial and error and eventual success, that I know all of its tricks or enough of them at least to prevent a more than temporary shut down of our laundry.

My greatest difficulty was similar to that of C. V.'s: the sticking contactors. It is necessary, of course, that the washer reverse, at intervals, determined by the setting of the timing mechanism. When the sticking occurred on our controller, there was no reversal and the machine would continue indefinitely in one direction. I tried everything I could think of for months. There was no bitumatic compound to cause sticking but I figured there must be something in the nature of residual magnetism in the magnet just strong enough to overcome the action of gravity and prevent a dropping out and back of the contactor when the circuit through magnet coil was broken. Acting on this idea, I put a weak rubber band around the contactor which pulled it out every time the magnetic pull was released. This was, of course, no correction of the difficulty but only a means to operate. It so happened that a coil burned out and I ordered a complete set. When the coils arrived, instead of replacing only the defective coil. I replaced every coil on the controller. The trouble stopped immediately and there has been no repetition of the same difficulty for a long time.

Peterborough, N. H. ARTHUR H. PARKER.

Lubricant Aids in Sealing Anti Friction Bearings

IN THE OPERATION of machinery fitted with anti friction bearings, we have become so accustomed to hearing of the low frictional characteristics of the bearings, and of their relative independence touching lubrication, that we are liable to educate ourselves to the point where lubrication will be practically ignored. If we would have our bearings give the utmost in length of life and in proper service, we cannot safely do this. While the actual load in a ball bearing or roller bearing is supported on a metal to metal, pure rolling contact, nevertheless, there are some places in all such bearings where sliding action takes place, and in consequence some lubricant must be present at all times to support this sliding action, as well as to protect the bearings against corrosion or rusting.

But there is another aspect to the lubrication of a ball or roller bearing that we must not overlook. Such bearings are provided with mechanical seals to exclude dust, dirt and foreign matter, but unless the bearing is properly lubricated, such seals cannot be entirely effective. Dust and grit will find its way in to some small extent, at least, unless there is enough lubricant present to form a seal by entering into all tiny openings that may be present, and thus completely excluding the dirt. It follows that maintenance costs can be lowered by giving periodical attention to all such bearings, sufficient to establish that they are receiving enough lubricant to serve this purpose.

Peoria, Ill. JOHN E. HYLER

Testing Motors for Bearing Wear

WITH MOTORS and dynamos fitted with plain bearings, wear of these is unavoidable with the result that with increasing wear the armature shaft is displaced. This displacement is likely to be made permanent if the bearings are badly adjusted for wear, the result is unequal air gaps between the armature and field poles which cause an unbalanced magnetic flux to pass through the armature and vibration and hammering in the bearings. It is usual to test the air gaps for length from time to time with feelers, so that the bearings can be suitably adjusted.

However another way to check the position of the armature shaft is this, in most cases the end of this shaft is accessible and also some non wearing part of the bearing housing. A horizontal line should be scribed on the end of the armature shaft and another on the bearing housing immediately below it. Measurement should be made between these two lines, as the machine continues in operation provided there has been no bearing wear or displacement of the armature shaft, subsequent measurement between these two lines will be the same as the original. If however bearing wear has occurred the distance between these two lines will be smaller. Any movement of the armature shaft from its original position in relation to the bearing housing will be accompanied by an equal alteration in the distance between the two marks made. Vertical marks can also be made on the shaft and bearing housing so as to show any movement in this plane also.

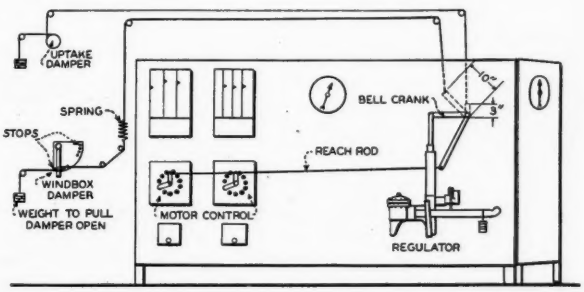
The lines previously described should be made when the whole machine has been reconditioned or is new and consequently all the air gaps are equal. The distance between the two lines can easily be measured with dividers, the original measurement should be noted down, and when measurements are afterward made they should be compared with the original. The differences between the two readings will show if adjustment is necessary or not. The advantage of this method of checking the air gaps is that it can be done with much less dismantling and inconvenience than the older feeler test.

Kent, England. W. E. WARNER.

Damper Regulators

RECENTLY on a 215 hp. boiler, carrying a load ranging from 200 to 550 b.hp., we installed a damper regulator as shown on the sketch. This saved a noticeable amount of fuel, at the same time we are able to operate practically without manual adjustments and maintain a thin veil of smoke at the top of the stack. The wind box pressure ranges from 7/8 to 1¾ in.; the overfire air a very slight draft; the second pass draft from 0.10 to 0.14 in.; the uptake draft from 0.12+ to 0.20 in.

The regulator is connected to an inverted bell crank and a reach rod connects this crank to the variable speed motor control switch in front of the panel. The bell crank shaft passes through a flanged brass bearing fastened to the panel with flat head machine screws. A double arm is fastened to the shaft in the rear.



As the damper needs a small movement, relatively slow, the damper control is fastened to a short arm placed so as to be vertical at the point of damper cut-off. Strict attention must be paid to this location and the length of the arm. As shown in the sketch, angular motion of the shaft has a minimum effect on the damper with the arm located at the vertical position as shown.

The windbox damper on the other hand needs more movement and must move faster. This is obtained by means of a longer arm which swings about a horizontal axis where angular movement of the shaft has maximum effect on the damper movement.

The stack damper arm is set in a vertical position with the damper closed. The wind-box damper arm is set in its extreme top position with the damper closed and this places the long, or wind-box, regulator arm, about 45 deg. in advance of the stack damper arm. The wind-box damper must have a stop to keep it from closing too far and another stop to prevent it from going beyond the wide open position, and a spring should be inserted as shown to prevent breaks when the damper comes against the stop.

Toledo, Ohio. FRANK CAUFFIELD.

New Use for a Drinking Straw

AN ORDINARY TYPE DRINKING straw, made of paper, is handy at times when it is desired to lubricate parts of electrical apparatus. A drinking straw being a non conductor of electricity at low voltage, permits oil to be applied to equipment without the danger of electric shock or of personal injury or damage to the equipment due to a short circuit caused by the metal spout of an ordinary oil can of the pump or spring metal bottom type.

A section of the straw may be cut off so as to shorten the length of the straw for the purpose of applying oil to parts of ordinary machinery where the length of an ordinary oiler spout is too long to permit the oiler to be used.

In using a straw for this purpose, the straw is inserted into a container of lubricating oil as shown in Fig. 1. The oil will rise in the straw to approximately the level of the oil in the container. The finger is then held to the top end of the straw as shown in Fig. 2. This prevents air from entering the top of the straw when it is removed from the container of oil. Since air can not enter on top of the oil, a vacuum is formed, preventing the oil from flowing out of the straw.

Baltimore, Md. THOMAS TRAIL.

EDITOR'S NOTE:

The simple expedient resorted to above brings to mind similar contrivances which can often be used under various conditions. A piece of soft glass tubing can be used in much the same way when it is neces-

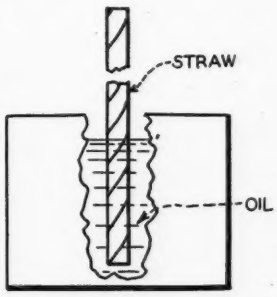


FIG. 1

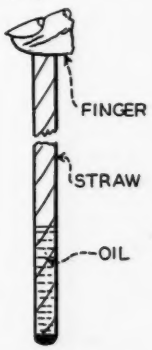


FIG. 2

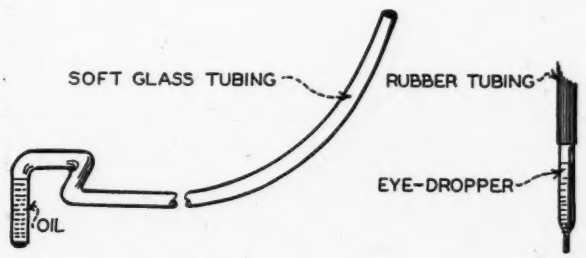


FIG. 3

FIG. 4

sary to oil a remote place impossible to reach with an ordinary oil can.

The tubing may be heated and bent to the desired shape and filled with oil as above.

An eye-dropper with the rubber bulb removed and a piece of rubber tubing attached may be lowered a considerable distance and used in a like manner.

Movement of Keys

PROVIDED keys have been properly fitted in the first instance and they have been kept free of oil and grease, they will remain firm for many years. Some keys, however, will collect a thick coating of dull red powder. This is oxide of iron which has probably been abraded from the key when first installed and then oxidized due to contact with the atmosphere. Its presence is usually proof of movement of the key which should be tested for slackness by ringing with a hammer and noting if there is any variation in the sound. If so, the key is not making contact all along its length. Another method of testing is to apply a solution of red lead and paraffin oil to the key and its surroundings. Then wipe the keyway dry and try moving one of the parts joined by the key. If there is the slightest slackness of the key, red lead and oil will be squeezed out of the space at the side of the key.

Kent, England. W. E. WARNER.

Compressor Overload

Q. In the October issue, Page 589, you answered a question for an engineer and I am sure that there must be a misprint or a typographical error in your answer because you state that at one pound of suction pressure less horsepower is required than at 15 lb.

My calculations show that with one pound suction pressure and 151.7 lb. head pressure requires 1.548 horsepower per ton, at 15 lb. suction pressure and 151.7 lb. head pressure requires 1.308 horsepower per ton.

Am I correct in my assumption and in my calculations?

C. F.

A. The general idea of your calculations in the second paragraph are correct, but I do not get the same values for actual practice. It may be possible the values you have chosen are theoretical and for this reason do not check with my values. At 1 lb. suction and 154.5 lb. discharge, I get 2.16 and at 15 lb., 1.48 b.h.p. per ton.

Please bear in mind that these values are all based on a ton refrigeration. As you will recall, the problem in question is based on a 7 by 7 in. compressor at 350 r.p.m. This compressor at 15 lb. would develop about 21.5 tons refrigeration and at 1 lb. only about 10 tons refrigeration. Therefore, you will see that the compressor would require approximately 21.6 h.p. at 1-lb. and 31.8 h.p. at 15-lb.

It is true that the brake horsepower per ton increases at the low suction pressures but the tonnage and brake horsepower of the compressor have both decreased to a point where the total brake horsepower is lower at the low back pressure than at the high back pressure. Therefore, your conception of increased brake horsepower per ton at the low back pressure is correct, even though we both do not check the same values.

In the December issue of "Power Plant Engineering" is an article giving a full description of compressor capacities and an example of calculations.

Waynesboro, Pa. W. R. KITZMILLER.

Anti-Friction Bearings of Too Light Weight

MANY TIMES it is desired to change a machine or piece of equipment over from plain to anti-friction bearings, but there is considerable hesitancy about the matter, because it is found that the initial cost of the anti-friction bearing is considerably greater. Then, after a careful consideration of the benefits to be obtained in the way of lowered maintenance costs, savings in lubrication and other factors, it is fully decided to make the change. The original thought, however, of the higher initial cost remains in mind, and care is exercised to see that this cost runs no higher than is necessary.

One thing overlooked at this point in a great many cases is that the weight or size of a bearing, as well as its accuracy in manufacture, has much to do with its life. Take the finest kind of a bearing, but one too light for the duty it is called on to perform, and its life will be very much shortened. Above all other things, when installing anti-friction bearings, do not allow the thought of cutting down initial cost to lead to the selection of too cheap or too light a bearing. If there is any doubt whatever as to the ability of a given bearing to give the best service in a given location, take the matter up with a reputable bearing manufacturer before coming to a final decision. If the manufacturer is willing to guarantee the performance of the bearing for the duty stipulated, there will be little chance of trouble developing after the installation.

Peoria, Ill. JOHN E. HYLER.

An Erroneous Statement Corrected

I HAVE before me a printed publication in which a statement is made concerning baffling of boiler tubes under temperatures up to 3300 deg. F.

Boiler tubes that contain water are always comparatively cool. They are never as hot as 3000 deg. F., nor 2000 deg., nor even 1500 deg. I have before me a steam table published by a manufacturer of superheaters which shows that even where the steam pressure is 3300 lb. per sq. in. the temperature of the steam is only 705 deg. F., and under no circumstances do they advocate superheat of more than 300 deg. making the maximum possible steam temperature about 1000 deg. F. At the same time it must be remembered that superheaters are seldom baffled. The baffle walls make contact with tubes that are always cooler than 1000 deg. F. In fact, as already stated, the water in the hottest tubes will never have a higher temperature than 705 deg. F. That is why I call the tubes "cool" as compared with the temperature in the furnace. Certainly these comparatively cool tubes will never permit the temperature of the baffle to reach 3300 deg. F.

Newark, N. J. W. F. SCHAPHORST.

Edison Electric Institute Convention *in* St. Louis

THE FOURTH ANNUAL CONVENTION of the Edison Electric Institute will be held at St. Louis, Mo., June 1 to 4. Indications point to its becoming the best attended public utility gathering in recent years and arrangements for a very interesting program have been made.

The business sessions have been planned for the maximum of usefulness and convenience to delegates. Five general sessions are scheduled, the first to be held Monday afternoon, June 1st, at 2:30 p. m. The registration desk will be open Monday morning. The registration desk and business offices of the Convention will be located in the Municipal Auditorium, where the general and committee meetings will be held.

The program is as follows:

Monday Afternoon, June 1st, 2:30 to 5:30 P. M.

Call to Order
Welcoming Remarks
"The Cost of Electric Service"—Norman R. Gibson, Buffalo Niagara and Eastern Power Corp.
"Twenty-five Years of Rate Reductions"—W. G. Vincent, Pacific Gas and Electric Co.
"Fundamentals of Utility Accounting"—L. R. Nash, Stone and Webster Engineering Corp.
"Aboriginal Cost"—H. L. Gruehn, Consolidated Gas, Electric Light and Power Co., Baltimore
"Continuous Inventories"—H. B. Gear, Commonwealth Edison Co.
"Costliness of Elaboration in Regularly Compiled Accounts"—C. E. Kohlhepp, Wisconsin Public Service Corp.
"Merchandising Accounting"—W. H. Swinney, West Penn Power Co.

Tuesday Morning, June 2nd, 9:30 A. M. to 12 M.

"The Kitchen Modernizing Program"—G. E. Whitwell, Philadelphia Electric Co.
President's Address
Address—J. F. Owens, Oklahoma Gas and Electric Co.
"American Enterprise"—Harper Sibley, President, Chamber of Commerce of the United States

Wednesday Morning, June 3rd, 9:30 A. M. to 12 M.

"Firm Ratings"—S. M. Dean, The Detroit Edison Co.
"Present Aspects of Utility Financing"—C. W. Kellogg, Engineers Public Service Corp.
"Farm Electrification"—W. W. Freeman, Columbia Gas and Electric Corp.
Farm Electrification by an Operating Executive
"New Developments in Farm Wiring"—E. A. Brand, Niagara Hudson Power Corp.
"Developments in Farm Lines"—A. E. Silver, Ebasco Services, Inc.

Wednesday Afternoon, June 3rd, 2:30 to 5:00 P. M.

"National Sales Programs Create Better Understanding"—G. W. Allison, Edison Electric Institute
Address—Frank T. Post, The Washington Water Power Co.
"A National Program for Prevention of Blindness and Conserving Eyesight"—Lewis H. Carris, Managing Director, National Society for the Prevention of Blindness
"Review of Utilities' Position in Air Conditioning Field"—C. E. Michel, Union Electric Light and Power Co., St. Louis
Discussion—Room Cooling with Portable Units
House Ventilation Through the Attic
"Three Decades of Utility Sales Development"—C. E. Greenwood, Edison Electric Institute

Thursday Morning, June 4th, 9:30 A. M. to 12 M.

"How Can They Know?" (The Employees' Attitude)—Dr. Adam. S. Bennion, Utah Power and Light Co.
"The Outlook for the Electric Power Industry"—Prof. Philip Cabot, Harvard University
Announcement of Prize Awards
Announcement of New Officers

On Monday, June 1st, a card party will be held at Glen Echo Country Club, St. Louis, Mo., for the ladies attending the convention. Buses will leave the Hotel Jefferson, 12th and Locust Sts., promptly at 2:30 p.m. for the Club, returning about 6 p.m. There will be tables for cards, and for those who do not play cards, games will be provided. Prizes will be offered at each table and for the games. There will be dancing on Monday and Tuesday evenings in the Gold Ballroom of the Jefferson Hotel, and a concert in this room on Wednesday evening at 9 p.m.

A sight-seeing tour has been planned for Tuesday afternoon, June 2nd. All delegates attending the convention are invited to attend. The buses will leave the Jefferson Hotel at 2:30 p.m., returning about 5:30 p.m. Reservation cards may be secured at time of registering.

A circular, giving rates and locations of the principal St. Louis hotels, together with reservation blank has been sent to all members of the Institute. Reservations should be sent direct to the hotel of first choice.

The Passenger Associations have authorized, on the Indentification Certificate Plan, a reduced rate of a fare and a third for the round trip from all points of the United States and Canada, with return limit of 30 days from date of sale.

Latest Equipment Displayed at Power Show

AS THE DOORS of the International Amphitheatre swung shut on the Seventh Midwest Engineering & Power Exposition, a chapter of power show history was definitely closed. For a decade this exhibition, popularly known as the Chicago Power Show, has offered manufacturers the opportunity of displaying equipment advances to middle west engineers, but at the Midwest Conference banquet announcement was made that the name would be changed to "The Power Show of the Power Industry." Whether this new show, under the same management and with the same policies, will continue in the popular mind as the Chicago Power Show remains to be seen.

Grouped in two halls of the new amphitheatre at the Stockyards, the exhibits were varied, offering the spectator a wide range of equipment and materials from insulated houses to automobile chassis. The majority of power equipment consisted of accessories, those items so important to the power plant and industrial engineer if the performance built into a plant is to be attained.

As with past shows, booths of the manufacturers representatives in the Chicago area played an important part. The Automatic Primer Co. featured its automatic priming unit for centrifugal pumps by means of a working exhibit and displayed the products of other manufacturers which they represent. These include: the Condenser Service & Engineering Co.; the Instrument Service Co. specializing in the rebuilding of all types of instruments; Blackburn-Smith Mfg. Co. filters and the Mosinee continuous blow down manufactured by the Mosinee Power Service Corp.

Working models of Armstrong Machine Works traps, with glass bodies to demonstrate the operating principles, formed the central display of Barrett-Christie Co., around which were grouped regulators and control equipment of Mason-Neilan Regulator Co., return traps of the Johnson Corp. and valves and instruments of the Consolidated-Ashcroft-Hancock Co.

Faville-LeValley Corp. specialized in models and full size equipment. These included a Radiojet of C. H. Wheeler Mfg. Co., the Stowe Stoker manufactured by Johnston & Jennings Co.; Fuller Co. rotary compressors and vacuum pumps and non segregating coal spouts of the Stock Engineering Co.

Full sized sections of the Brydon curved air grates designed for burning low grade coals, screenings, small anthracite, etc., were displayed by Ernest E. Lee Co.

Blowers and vacuum cleaning systems of Allen Billmyre Corp.; ring crushers of the American Pulverizer Co.; products of 48 Insulations, etc., and manometers of the Merriam Co. were shown by Mayer & Oswald, Inc.

Coal, an important item in the operation of a power plant, was not neglected. Different kinds and sizes of coal from the Illinois, West Virginia and Kentucky fields were shown by the Old Ben Coal Corp.; methods of using scales to weigh coal and check up on plant efficiency were explained and demonstrated by a late model coal scale by the Richardson Scale Co. and economical coal handling by the drag line scraper was demonstrated by a working model at the Sauerman Bros. exhibit.

This matter of plant efficiency and control is extremely important. Schutte & Koerting Co. had a complete line of Rotameters in operation and in addition showed a four stage steam jet vacuum pump commonly rated at four pounds of air at 1 mm. vacuum. Marshalltown Mfg. Co. had a complete line of industrial gages and air filters.

Combustion control equipment was much in evidence with full size equipment in operation. Askania Regulator Co. showed operating and cut-away models to demonstrate the principle of its jet pipe system of control; A. W. Cash Co. demonstrated the operation of its varied line of hydraulic control equipment and control specialties; Shallcross Controls, Inc., exhibited its latest models now made for operating steam pressures up to 400 lb.

Packing and insulation, two very important items in the plant, were also well represented. Durametallic Corp. had a working exhibit and also displayed all types of packing and tools for its application. Household insulation with The Eagle-Picher Sales Co. products was shown in a small house display by The Becker Roofing Co. A complete line of flax, woven copper, hydraulic and sheet packing was displayed by the Ehret Magnesia Mfg. Co., Inc., who, however, featured Ply-Lubro, a corrosion preventative and lubricant, and Fibrekote, an asphalt emulsion containing asbestos fibres and used as a weather proof protection for all thermal insulations. Felt Products Mfg. Co. had a complete line of gaskets and packing for all uses. Garlock Packing Co. featured Klozure, an oil seal for shafts, by means of a large size working model. Insulations, refractories and packings of all kinds formed the exhibit of Johns-Manville Corp.

As might be expected, power transmission exhibits formed the largest single group of exhibitors. The Power Transmission Council used an effective demonstration to compare modern group with individual motor drive. Howell Electric Motors Co. displayed its line of small motors. Rockwood Mfg. Co. featured its pivoted motor drive for various applications and with different arrangements of pulleys and V-belts. V-belts were also a feature of the Chicago Pulley and Shafting

Co. booth where Dayton Cog belts competed for attention with S-K-F bearings. Application of all types of flat belt drives and leather packing for pistons was effectively demonstrated by the Chicago Belting Co. by means of a new board, with moving displays.

Different types of hangars and anti-friction bearings formed the basis of the Ahlberg Bearing Co. exhibit. Cleveland Worm & Gear Co. had a complete display of gears and gear units from the smallest to the largest. Gears and anti-friction bearings of the Nice Ball Bearing Co. were featured by Gears & Transmission, Inc. The Universal Gear Co. displayed geared motor units and featured the Speed-Trol with a variable range of 80 to 1. Principles of hydraulic couplings for variable speed service were featured by the Hydraulic Coupling Corp. Different types of L-R flexible couplings covered a range of from 1/12 to 1200 hp. were demonstrated in the exhibit of the Lovejoy Tool Works.

Lubrication was the basis of an attractive group of exhibits. Wm. W. Nugent & Co. featured pressure filters in operation and displayed its varied line of oiling devices. Socony-Vacuum Oil Co. used an animated model depicting the part lubrication played in a pageant of American progress. Standard Oil Co. displayed in an attractive way its line of oils and greases. The Texas Co. built its exhibit around a model Diesel engine motor driven to simulate actual operation.

Transportation and handling of materials for industry were featured by three companies. The Automatic Transportation Co. displayed lift trucks; Mercury Mfg. Co. gasoline and electric "Trackless Trains"; while Yale & Towne Mfg. Co. featured trucks and hoists by means of equipment and movies.

Pipe tools for all services were shown in operation by Beaver Pipe Tools, Inc. Other tool exhibits included a display car of tools made by the Bog Mfg. Co.; small tools, taps and dies by the Greenfield Tap & Die Corp.; and pipe tools by The Ridge Tool Co. Portable electric tools for construction and maintenance were demonstrated by the Skilsaw Co., Inc., and abrasive tools and cutters by A. P. de Sanno & Sons, Inc. Gasoline driven tampers and concrete breakers were shown by the Barco Mfg. Co. along with a complete line of its universal joint for service with fluid pipe lines. Clements Mfg. Co. demonstrated portable blower units and spray guns.

Many of the exhibits are, of course, hard to classify, for instance the extensive display of the various units of the Union Carbide & Carbon Corp., including welding equipment of The Linde Air Products Co., hard facing of valves and other parts with products of Haynes Stellite Co. and alloy steels of the Electro Metallurgical Corp.

Unit heaters and convectors of modern design were featured by the Modine Mfg. Co. Electric air heaters of all kinds were shown by the Electric Air Heater Co. Arthur Harris & Co. had an extensive exhibit of stainless steel and copper floats.

The new rotary screw strainer was featured in the extensive exhibit of Sarco, Co., Inc., which included their other products, regulators and traps.

Electrical exhibits were few but effective. Bull Dog Electric Products Co. featured its new Vacu-Break switch. U.S.L. Battery Corp. its storage batteries for industrial and control purposes. Walter Kidde & Co. demonstrated small fire extinguishers and showed their application of the Lux CO_2 system to electrical equipment by movies.

Although boilers were represented by but a single exhibit, auxiliary boiler equipment was much in evidence. The single boiler exhibit was by the Dual Combustion Corp. which showed its boiler and pulverizer units and also the application of Controlled Heat Equipment Co. superheater. Combustion Aid Co. demonstrated by means of photos application of its steam jet system. Air cooled furnace walls were featured by the Metal Furnace Block Co. by means of a full sized section of wall. High and low pressure gas burner as made by Lee B. Mettler Co. were displayed in the booth of James M. Kobak Co. and oil burners of the Todd Combustion Equipment Co. in the booth of the Mid-West Heat Service Co.

Adjustable inclined gage glass and water column equipment was displayed by the Ernst Water Column & Gage Co. which featured round gage glasses for pressures up to 2000 lb. and also the new design of Split-Gland water gage.

Water treatment, so important to the modern boiler, was much in evidence. The Burgess Industries exhibited, among their other varied products, such as silencers, flashers and acoustical materials, Zeolite for water softening and Birm for the removal of iron from industrial and domestic water supplies. Dearborn Chemical Co. featured its water treatment and methods of feeding, metal cleaners and No-Ox-Id metal protection. National Aluminate Corp. demonstrated the application and feeding of Nalco treatment and showed representative installations by means of photographs.

Boulder Dam

Boulder Dam as the largest power project yet completed created considerable interest, Allis-Chalmers Mfg. Co. exhibited a small model of the dam and power plant, a model of one of the 115,000 hp. turbine runners and a large scale drawing of one of these same units. The dam, 730 ft. high, contains 3,250,000 cu. yd. of concrete.

Diesels were represented by two manufacturers, Caterpillar Tractor Co. had one of its new industrial units consisting of an engine direct connected to a 50 kv-a. generator. Hill Diesel Engine Co. exhibited a 45 hp., 720 r.p.m. Diesel as a representative of its line of stationary and marine engines. Diesels, of course, need piston rings and air filters. This need was well taken care of by an extensive display of C. Lee Cook Mfg. Co. piston rings and Air-Maze filters in the booth of Cooktite Ring Sales Co.

Interspaced with the manufacturers' exhibits were displays by various institutions in the Chicago district, including: Armour Institute of Technology, City of Chicago, Hays School of Combustion, Hemphill Diesel Schools, Lewis Institute, Machinery & Allied Products Institute, Commonwealth Edison Co., Museum of Science and Industry, National Safety Council, Purdue University, Public Service Co. These exhibits included modern and scientific instruments for industrial and research purposes and of historical interest.

New Equipment

Compressor Valves

RECENTLY Ingersoll-Rand Co., Phillipsburg, N. J., announced the Channel Valve a new development of importance to air and gas compressor users.

The only moving parts of the new valve are a number of valve channels, within each of which is a flat spring. The spring fits snugly within the channels so that when the valves lift, the springs straighten and a small quantity of air is trapped between springs and channels. Thus are formed air cushions which

decelerate the valve channels after opening and bring them to a stop softly and quietly without impact.

Valve channels are light in weight, their channel form being relied upon for strength and rigidity. They lift straight off the seat without flexing, returning to the same position. Springs are designed solely as springs because they are not called upon to act as valves.

Practically all new I-R compressors are being furnished equipped with the Channel Valve.

Voltage Regulators

TWO NEW, lower ratings in the Type GDA generator-voltage regulators have been announced by the General Electric Company. They are for a.c. machines up to 375 kv-a., at 3600 r.p.m., and smaller ratings at correspondingly lower speeds. The type designations are GDA-1M and GDA-1.

As in the GDA regulators of higher ratings previously presented, the new regulators have no vibrating contacts, the voltage-sensitive element being a form of torque motor balanced against a spring, and controlled by generator voltage. At any applied voltage within the range of the regulator, the armature of the torque motor assumes a corresponding deflection against the restoring torque of the spring. This element then remains motionless unless a change in voltage occurs, in which case a proportional change in deflection takes place. The action of the regulator is stabilized by a transformer-type stabilizer. This device obviates the need for dashpots or other anti-hunting devices and does not require the maintenance necessary with other types of equipment.

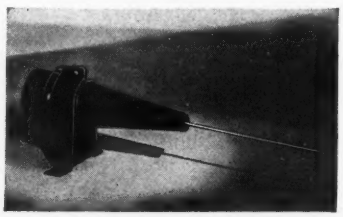
Response of the torque motor element is fast and possesses a flat characteristic with respect to load, frequency, and temperature. In all the regulators, the regulating system remains at rest unless an actual change in generator excitation becomes necessary to maintain voltage.

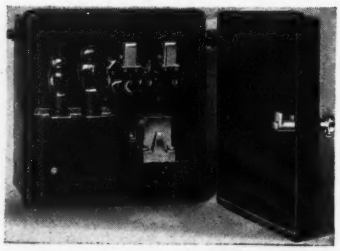
Both new regulators are direct-acting, that is, the rheostatic element is an integral part of the regulator unit and is actuated directly by the voltage-sensitive regulating device. The rheostatic element is of the new type construction employed in the three previously announced GDA regulators which provides a smooth change in resistance from almost zero to a maximum in a great number of very small steps. The rheostat is small and compact and is operated directly by the torque motor through a simple linkage.

Only six leads are required for the regulator—two for the potential circuit, two for the exciter shunt-field circuit, and two for the stabilizer. Since the torque motor is a d.c. device, a small, full-wave copper-oxide rectifier is used to convert the a.c. potential of the generator for application to the torque motor.

Combustion Safeguard

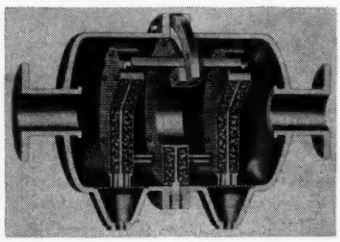
THE BROWN INSTRUMENT CO., a division of the Minneapolis Honeywell Regulator Co., Philadelphia, Pa., has announced a new line of "Protectoglo" equipment for use in connection with combustion safeguard systems in furnaces. This system utilizes the electrical conducting property of a flame and consists simply of an electrode projecting into the flame and suitable electron tube and relay equipment so arranged that the system is shut down when the flame fails. An 80 tube supplies rectified current to the system which also includes an amplifying tube to attain the desired degree of sensitivity. The tubes and relays are mounted in a cast iron case remote from the electrode unit. With these devices a system of combustion safeguard can be supplied for practically any type of burner equipment.





Purifier

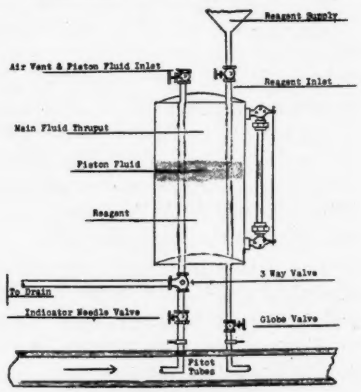
MOREHEAD MANUFACTURING CO., Detroit, Mich., announces a new purifier and drier for exhaust steam, air and gases, known as Exhausteam Purifier and Drier, which combines well known mechanical principles for the removal of moisture, oil and solid impurities ordinarily entrained by steam. Among the treatments to which the steam is subjected are: sudden reduction in velocity; sudden deflection by baffling; centrifugal force; capillary action.



It is claimed that clean, dry exhaust steam that may be safely substituted for live steam in heaters, driers, evaporators, stills, cooking kettles, digesters, vulcanizers and special process equipment, is provided by this unit. Likewise, this clean steam will yield a pure, soft condensate for boiler feeding and other purposes at additional savings.

Chemical Feeders

D. W. HAERING & CO., INC., 3408 Monroe St., Chicago, Ill., announce the introduction and development of three new proportioning machines employing the direct transmission of pressure differentials from pitot tubes and utilizing liquids as fluid pistons. The new Model "A" Feeder illustrated is a low priced accurate proportioning unit. The design of the new Model "A" Feeder makes possible the application of proportioning units in service where initial costs have previously been prohibitive. Model "E," or the corrosive solution feeder, has been constructed so as to provide sight feed indication for the first time. It is now possible to feed such solutions as hypochlorite, sulphuric acid and ferric chloride and count the number of drops being fed per minute. Model "F" Feeder for feeding oils and organic solvents into gasoline, oil or gas lines, represents an entirely new application of the fluid piston principle. The new units announced, herewith, have been the result of demand for the application of proportioning principles

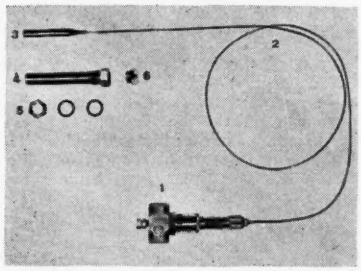


introduced by D. W. Haering & Co., Inc., to the problems of specific industries.

A new twelve page booklet describing these units in detail will be available for distribution shortly.

Control Valve

YARNALL-WARING Co., Chestnut Hill, Philadelphia, Pa., announces the Yarway automatic steam control valve designed for connection to the outlet or condensate end of steam heating coils in water heaters and in various types of industrial process equipment, in which close regulation of temperature is required. When so connected, this valve eliminates steam regulators and steam traps and frequently does



away with pressure reducing valves. The Yarway Control may also be used on the inlet end of the coil.

Valve body is made of cold rolled steel, disc and seat of stainless steel, stem of tobin bronze and bonnet of brass. Valve shown is ½" size, suitable for steam pressures up to 125 pounds.

Silmo Steel

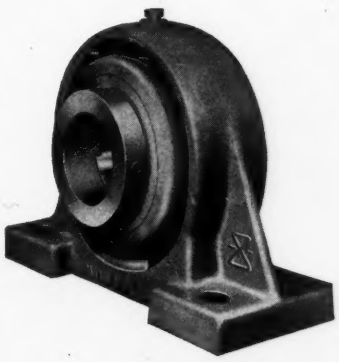
THE TIMKIN STEEL & TUBE Co., Canton, O., has just announced a new steel designated as "Silmo," especially designed for applications where an economical combination of high temperature strength and oxidation resistance is required. In the temperature range of 1000-1200 deg. F. "Silmo" steel has about twice the strength of carbon steel and its oxidation resistance compares favorably with that of 4-6 per cent Cr-Mo steel. This new steel may be used to replace carbon steel where greater safety is required and as a substitute for the standard carbon molybdenum steel where oxidizing conditions are encountered. Indicated uses for "Silmo" steel lie in the field of cracking furnace tubes, pipe still heater tubes, high pressure boiler and superheater tubes, and tubing used in the manufacture of air heating equipment.

ANNOUNCEMENT has been made by The Curran Corp., Malden, Mass., of a new cleaning and degreasing fluid to be known as "Gunk," a self-emulsifying solvent which has the unique and valuable properties of causing oil and water to mix perfectly. Gunk does not form a mechanical mixture of oil and water but mineral oils and greases treated with it form stable emulsions with cold water.

CONICAL NON-SEGREGATING Coal Distributors are described in a new bulletin recently published by Stock Engineering Co., Penton Bldg., Cleveland, Ohio. The bulletin describes how segregation occurs and illustrates how it is eliminated by the use of these distributors.

Pillow Block

TO SIMPLIFY alignment of shafts and to take care of light or heavy shock loads at either high or low speeds, the Palmer-Bee Co., Detroit, Mich., has developed the self-aligning pillow block shown here. Among its distinctive features is its ability to withstand a greater shock

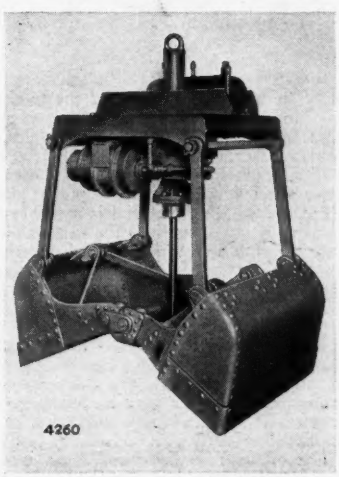


load than a shaft of corresponding diameter. This is due to the housing construction which is of cast steel. The bearing operates on a true ball and socket principle that permits a free oscillating movement of about 3 deg. maximum in any direction and at the same time maintains an unbinding accurate alignment of shafts. The pillow block is mounted with a Hyatt heavy duty precision bearing in a machine finished housing made dust and dirt proof.

Clam Shell Bucket

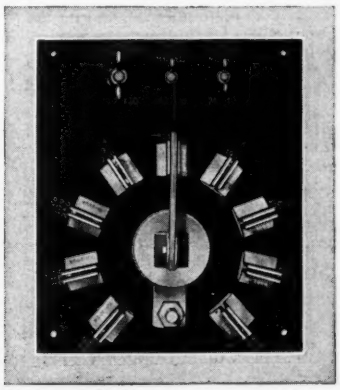
HAYWARD ELECTRIC-HYDRAULIC BUCKET is a new and improved type of clam shell bucket recently announced by The Hayward Co., 50 Church St., New York, N. Y., and is operated by means of a motor-driven fluid pump controlling a hydraulic ram.

This new bucket can be hooked on to a crane, electric hoist or ordinary derrick. Opening and closing are accomplished by a direct connected electric motor, controlled from the operator's cab.



Welder Switch

TO OVERCOME confusion and complications resulting from various controls used in connection with a. c. welders, The Miller Electric Mfg. Co., Inc., has perfected a rotary knife switch control which brings all the amperage changes under one switch

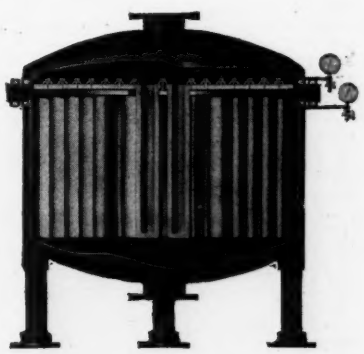


arrangement. This switch, distinctly marked in amperes so the operator knows exactly what amperage he is getting under any setting of the switch, is of heavy duty construction. Contact between knife blade and the welding lead is made through a large copper disk of heavy carrying capacity. The switch can be rotated in either direction.

With the announcement of this improvement the Miller Electric Mfg. Co., Inc., announces that henceforth the entire sales of the Miller Electric Welder will be handled by Giant Grip Mfg. Co., Oshkosh, Wisconsin.

Feedwater Filter

R. P. ADAMS Co., 220 Delaware Ave., Buffalo, N. Y., announce a new porous stone boiler feedwater filter designed for the removal of oil and other impurities from boiler feedwater. The filter is intended to be used following a chemical treatment such as alum for coagulating



the oil, the filter elements then removing the coagulant. The filter may be cleaned by introducing live steam in the reverse direction, flushing the coagulated oil from the bottom outlet to the sewer. The filter is not affected by high pressures and temperatures as it is made at a temperature of 2000 deg. F. and is of rugged construction.

Protective Panel

FOR USE in protecting the electrical equipment used on electrically-operated cranes, of the overhead traveling, locomotive and similar types, The Electric Controller & Mfg. Company, Cleveland, Ohio, announce a complete line of new Crane Protective Panels. These Protective Panels are used in place of circuit breakers, knife switches, fuses, etc., which are otherwise necessary in the crane cab, and incorporate all of the necessary protective devices into a single, compact unit requiring a minimum amount of space.

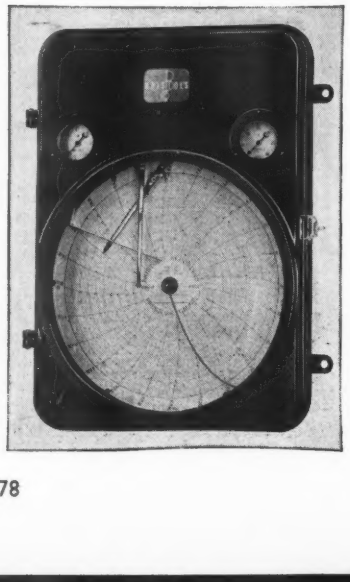
They are complete with main line contactors, knife switch, receptacles for pilot lights to show the operator when power to the crane is alive, an instantaneous overload relay in one side of the line, and an inverse time element overload relay in the opposite side of the line for each motor and a separately mounted push button for closing the contactors or resetting them after they have been tripped by an overload. Two single pole contactors are used for the main line and are closed in sequence; this method of operation providing the feature that both are free to trip and will open immediately if an overload exists.

Recorder-Controller

THE BRISTOL CO., Waterbury, Conn., announces a new series of pneumatic-type controllers known as Ampliset Free-Vane Controllers. These instruments are now available for automatically controlling temperature, time-temperature, flow, liquid level, pressure, time-pressure, and humidity. The Ampliset principle has also been combined with the Metameter, a system of telemetering recently announced by this company, for the remote control of steam pressure and gas pressure.

Certain features of field adjustability have been added to the Free-Vane System, whereby its sensitivity can be changed by means of a small screw driver to exactly fit the lag peculiarities of the process on which it is used. The sensitivity or throttling range of the instrument can be changed without removing the chart or chart dial or disturbing the operation of the controller or upsetting the operation or equilibrium of the process.

By the same adjustment that regulates the sensitivity of the Ampliset Controller, the instrument can be changed from direct-acting to reverse-acting or vice versa. This change is made by simply turning the scale on the adjustment past the zero point.



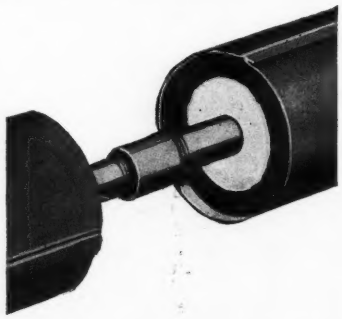
Hydraulic Valves

TO THE LINE of hydraulic valves manufactured by W. H. Nicholson & Co., Wilkes-Barre, Pa., has been added Style H designed for oil or water service at pressures up to 5000 lb. per sq. in. in 2, 3 and 4-way types. It is furnished with a body of either electric furnace cast steel or Super-strength bronze, stem of monel metal, base of hardened stainless steel, disc of Everbrite metal or bronze and lever of steel.

In construction, an exceptionally large diameter stem is used which is connected to the disc by means of a large area bolt and in conjunction with the disc, acts on the principle of a differential piston. Pressure is always maintained in the body of the valve, exerting force downward on the disc with its larger area, and upward on the stem with its somewhat smaller area, thus the valve is balanced.

Insulated Pipe

DURANT INSULATED PIPE is announced as a new product of the Ehret Magnesia Mfg. Co., Valley Forge, Pa. It is adaptable to either hot or cold service in underground or outdoor locations. The complete unit consists of specified pipe next to which has been applied insulation in proper thickness, usually 85 per cent magnesia for steam or hot water, and over the insulation has been applied a thick, airtight coating of non-porous asphalt. To protect the entire unit from surface damage, it is incased in a galvanized metal gas-



ket. The units are built up at the factory and shipped to the job in standard or special lengths where they are connected by means of standard pipe fittings and the insulation applied as described above, except that a sheet metal covering is put in place after the insulating material is applied and the asphalt is poured into the surrounding space through a slot in the metal covering.

Power Exchange

PLANS FOR interchange of large blocks of power between Pacific Gas & Electric Co. and Southern California Edison Co. through additional interconnections to be constructed between the two systems, were announced recently.

Completion of the connections, tentatively set for July of next year, will provide an outlet in central and northern California for a portion of the surplus created in southern California by the introduction of Boulder Dam power, a large part of which has been allocated to the Edison Co. under contract with the government.

The project also will relieve the two companies of the necessity of making further capital investments in plant capacity so long as either has any surplus power which can be transferred economically from one to the other.

In an application filed with the California State Railroad Commission in San Francisco, the Edison Co. and the San Joaquin Light & Power Corp., subsidiary of the Pacific Gas & Electric Co., asked approval of an agreement to construct large capacity interconnecting lines in the southern San Joaquin Valley, where transmission lines of the two systems are in close relation. Work is to begin immediately following approval of the agreement.

First of the interconnecting lines will be a connection with a capacity of 80,000 hp. between the Edison Co.'s substation at Magunden and the San Joaquin Co.'s system in the vicinity of Bakersfield. The plan also proposes construction of a high tension, 220,000-v. lines between the Edison Co.'s Big Creek No. 3 plant on the San Joaquin River and Herndon, southern terminus of the Pacific Gas & Electric Co.'s 220,000-v. transmission line from the northern part of the state. This new connection will be of sufficient capacity to allow the transfer of 280,000 hp. of electric energy.

A.I.E.E. Convention

THE SUMMER CONVENTION of the American Institute of Electrical Engineers to be held June 22-26 at Pasadena will afford members and guests an unusual opportunity to see many western developments and at the same time keep abreast of the profession. The schedule of events includes the annual business meeting and a technical session to be held during the mornings.

Many places of scenic or scientific interest will be visited during the convention and the large engineering projects, such as Boulder Dam, the Metropolitan Water District Aqueduct, San Francisco-Oakland Bay and Golden Gate Bridges, Bonneville Dam, and Grand Coulee may be visited as pre- or post-convention trips.

Technical subjects to be discussed include some of the new apparatus and equipment now being or recently installed on west coast projects, and among the contributors will be many well known eastern and western engineers. There will be two student technical sessions, one on Wednesday afternoon and the other on Friday afternoon.

New Diesel Engines

SULZER BROS. of Winterthur, Switzerland, has licensed, effective April 20, 1936, the American Locomotive Co. of New York to manufacture, use and sell Sulzer designed two-cycle Diesel engines. They will be built and offered in America by the McIntosh & Seymour Corp., Auburn, N. Y., a wholly owned subsidiary of the American Locomotive Co., under the trade-name,—Alco-Sulzer Diesel engines.

Sulzer Bros. was established in Winterthur, Switzerland, in 1834, but the name Sulzer has been identified with the metal working industry since 1775. They built their first steam boiler in 1841, their first steam engine in 1851 and in 1893, the year that Rudolf Diesel secured his first patent,

secured the manufacturing rights of the Diesel oil engine and have been actively engaged in Diesel engine development from the beginning.

Their first experimental engine was built in 1896 and manufacture on a large scale was taken up in 1903. The first Sulzer Diesel engine for marine purposes was installed in 1904. Their first directly reversible Diesel engine, the first of this kind ever built, was exhibited by Sulzer Bros. in 1906 at Milan Exhibition. Since then direct reversible two-cycle Sulzer Diesel engines have been built not only for submarines, harbor tugs, river boats and small and large cargo boats, but also for large passenger liners up to 20,000 hp. per engine or 40,000 hp. per ship.

Special attention has been devoted to two-cycle Diesel engine development and many large Sulzer units have been supplied to electric power stations in all parts of the world. The greatest power developed per cylinder is represented by a single cylinder of 2000 hp. The total output of Sulzer Diesel engines constructed up-to-date amounts to more than 4,500,000 hp.

Convention of S.P.A.

ALL PHASES of smoke prevention work will be discussed by nationally known authorities at the thirtieth annual convention of the Smoke Prevention Association to be held June 2 to 5 at Atlanta, Ga. Among the papers scheduled for the meeting are: Selection of Locomotive Fuels, by G. G. Richie; Influences Resulting from the Presence of Sulphur in Coals, by Thos. E. Shaughnessy; Present Day Developments in Smoke Elimination at Engine Terminals, by Don R. Goodwin; Bituminous Coal Industries Program, by John D. Battle; Coöperative Efforts Between Stoker Industry and Smoke Abatement Officials, by Marc Bluth; Practical Procedure for Inaugurating and Conducting Smoke Abatement Work in the Smaller Cities, by Wm. Culbert; Dirt Fall and Soot Collection Surveys, by Frank H. Lamping; Practical Smoke Abatement, by J. E. Bjorkholm; Value of Publicity in Smoke Abatement Work, by C. D. Behan.

N.D.H.A. Convention

FOR 4 days, from June 16 to 19, the National District Heating Association will hold its 27th Annual Convention at the Hotel Pantlind, Grand Rapids, Mich. A well rounded business and social program is planned and the annual banquet will be held on Thursday evening, June 18.

Preceding the convention proper, on Monday, June 15, there will be a conference on Steam Metering for those particularly interested in this subject. The primary purpose of this meeting is to bring about improvements in the apparatus and methods used in measuring steam.

Oil and Gas Meeting

SIX SESSIONS are scheduled for the annual meeting of the Oil and Gas Power Division of the American Society of Mechanical Engineers to be held at the University of Michigan, Ann Arbor, Mich., June 24 to 27.

Among the papers scheduled on the tentative program are: Diesel Engineering Training, F. G. Hechler; Effect of Legislation on Diesel Development, L. H. Morrison; Research Activities at University of Michigan; Bearing Design, Harte Cooke; Engine Governing and Speed Regulations, Frank Hodgkinson; Performance of Lubricants Based on Service Conditions, C. M. Larson; Diesel Operating and Maintenance Problems, L. M. Goldsmith; Vibration Control of Internal-Combustion Installations, S. Rosenzweig; Fuel Injection Spark-Ignition Oil Engine, N. Fodor; Diesel Fuel Research, M. J. Reed and A. E. Becker; Diesel Power Cost Report, H. C. Major.

Plant to be Enlarged

A TWO MILLION dollar project for the improvement of the Kansas City, Kan., municipal light plant was approved March 30 by the Board of Public Utilities and a citizen's advisory committee.

The projected improvements would increase capacity of the plant from 39,000 kw. to 69,000 kw. and includes plans for the installation of a 30,000-kw. generator. A 6000-hp. boiler also will be installed and switchboard modernization and improvement is planned. It will be necessary to increase the building area of the plant to 140 by 280 ft. to house the new equipment.

According to plans of the company, it will not be necessary to float a bond issue. Total cost of the plan is placed at approximately two million dollars, half of which is already available. An additional three hundred thousand dollars is available for working capital during progress of the work. Officials of the company estimate the works will require 2 yr. to complete.

James D. Donovan, manager of production and distribution, declared a saving of bond interest approximating $472,000 would be effected because of the cash now available for the work.

Fuels Conference

EXECUTIVES of eight industries and four trunk line railroads participated in the program of an Industrial Fuels Conference held in the Court House, Jersey City, N. J., on March 27, which was arranged by the Department of Smoke Regulation of Hudson County and held under its auspices. William G. Christy, Hudson County Smoke Abatement Engineer, presided at the meeting.

Several plants reported substantial savings in fuel as the result of boiler plant improvements. One concern whose name could not be made public reported a net saving of more than $16,000 a year in coal consumption due to installation of new boilers and automatic firing equipment. Harry Yunker, Chief Engineer of the Jersey City Printing Co., presented figures showing that his company saved $4000 in one year after putting in oil burners. The cost of the installation was paid out of the first year's saving in fuel.

L. P. Goodwin, manager of the Jersey City plant, Mallinckrodt Chemical Co., told those attending the Fuels Conference that his company invested $4000 in underfeed stokers nearly 4 yr. ago. This has resulted in economies in fuel used, averaging $2912 annually since the stokers were installed. A. M. Waller, Asst. Supt., Martin Dennis Co., Kearny, presented a paper showing the advantages of modern boiler and furnace equipment. A new boiler plant costing $40,000 is showing net returns of $4652 a year. Waller also mentioned an annual saving of $2200 worth of coal used in their smelting furnaces due to installation of steam-air jets to eliminate smoke.

Definite action was taken at the Conference to form an industrial group for cooperating in elimination of smoke in the territory immediately across the Hudson River from New York City. An organization committee, appointed at the meeting, was authorized to formulate definite plans for organizing the 300 industries whose plants are located in Hudson County. The committee has decided to organize the Industrial Smoke Abatement Association of Hudson County. The governing body will be a Board of Directors consisting of seven officers and eight other directors.

A.S.M.E. at Dallas

AT THE SEMI-ANNUAL MEETING of the A.S.M.E. to be held in Dallas, June 15 to 20, an unusually complete program with 19 sessions has been arranged. Committee meetings will be held June 15 and 16, technical sessions on the 17, 18 and 19. Saturday, June 20, will be Engineers Day at the Texas Centennial Exposition and Dean A. A. Potter of Purdue, past president of the A.S.M.E. and president of the American Engineering Council will be the speaker. President W. L. Batt of the A.S.M.E. will speak at the luncheon on Wednesday, June 17.

Among the papers of interest to the power plant and industrial field are the following:

Cracked Residue Fuel Oils, by M. J. Hanlon; Analyzing Valuable Load for Disel and Steam Stations, by G. C. Boyer; Burning Gas, Oil, Coke and Sludges, by T. E. Crossan and A. J. Matherne, Jr.

Industrial Regulators, Their Theory and Application, by Ed. S. Smith, Jr.; The Flow of Saturated and Compressed Liquids Through Orifices, by Prof. M. C. Stuart and D. R. Yarnall; Fluid Meters Research, by Prof. H. V. Beck.

U. S. Army Airplane Maintenance System, by John H. Howard; The Use of the X-Ray Testing of Welded Vessels, by H. R. Isenburger; The Spraying of Molten Metal, by L. E. Kunkler.

Heat Transfer and Pressure Drop in Shell and Tube Exchangers, by Prof. B. E. Short.

Sensible and Latent Heat Control for Air Conditioning, by F. W. Rabe, Jr.; Air Conditioning in Humble Oil Co. Building, by A. C. Edwards; Air Conditioning The Robinson Gold Mine, by O. W. Bynum.

Vocational Training in the Southwest, by A. W. Breeland; Discussion of Air Corps Training, by H. W. Harms.

Chlorination of Circulating Water and Algae Control, by Robert R. Crodus; Heat Balance vs. Water Weighed Boiler Tests, by E. L. McDonald.

Economic Operating Cost Analysis of Electrified Pipe Lines, by W. H. Stueve; Steam Drilling Equipment, by V. M. Smith.

Sulphur Mining, by G. C. McMillan; Power and Heat Problems in the Sulphur Mining Industry, by C. L. Orr; Compressibility Determination without Volume Measurements, by E. S. Burnett.

Production of Helium, by C. W. Seibel; The Manufacture of Carbon Black, by Hilding Hanson.

Fuel Injection Spark Ignition Oil Engines, by N. Fodor; Diesel Fuels, by T. B. Rendel.

Pulverized Texas Lignite in Large Central Station, by N. G. Hardy; Operating Features of the 1450 lb. Deep Water Station, by H. G. Hiebler; Utilization of Natural Gas Fuel for Central Stations, by Elmer F. Schmidt.

Mechanization of the New Mexico Potash Mines, by H. I. Smith and R. V. Ageton; Development of the Air Float Method of Gravity Separation, by R. R. Slaymaker.

A Modern Rice Irrigation System, by Prof. W. B. Gregory; Irrigation Pump Equipment and Practice, by B. S. Nelson.

News From the Field

GEORGE D. POGUE, long identified with engineering, particularly in the Diesel engine field, died in New York City on May 3, 1936. He was born in Jerseyville, Ill., June 20, 1875, was educated in St. Louis and served his apprenticeship with the General Electric Co. at Schenectady. Following this he was employed by the Western Electric Co., Harrisburg Foundry & Machine Co., American Diesel Engine Co., Fulton Iron Works, Busch-Sulzer Bros-Diesel Engine Co. and Winton Engine Corp. Following this he retired to develop a spring-isolation system for engine and machine foundations. During his career he was granted more than 125 patents on mechanical and electrical devices.

LEONARD BISHTON-BOTFIELD, President of the Botfield Refractories Co., Philadelphia, and also President of the Canadian Botfield Refractories Co., Ltd., Canada, died on May 5 at Philadelphia, age 55. Mr. Botfield was affiliated with the refractories industry for many years, succeeding his father, A. Bishton-Botfield, as President of the Botfield Refractories Co. in 1916. He pioneered and was responsible for numerous important developments in the manufacture of high temperature cements, and was national chairman of the High Temperature Bonding Mortar Division of the American Refractories Institute and also a Director of the Institute.

LEE W. TREMBLAY, Witherspoon Building, Philadelphia, has been appointed sales representative for The Edward Valve & Mfg. Co., Inc., East Chicago, Ind.

ANNOUNCEMENT of the formation of The Bin-Dicator Company has recently been received. This company, organized to manufacture and market devices for automatic bin level indication and control, has taken over from the Ripley Manufacturing Co., at Wayne, Michigan, all business pertaining to the Bin-Dicator which is a device for indicating and controlling the level of bulk materials in bins or hoppers.

AMERICAN ENGINEERING Co. has moved its New York sales office from 40 West 40th Street to larger quarters in the Evening Post Building, 75 West Street, downtown New York.

PAUL O. STRIBLING, JR., has been appointed manager of the Detroit Stoker Co.'s district office at Charlotte, N. C. Mr. Stribling is a trained combustion engineer with a number of years of practical experience in the power plant field.

THE KENNEDY VALVE MANUFACTURING Co. of Elmira, N. Y., announces the appointment of R. M. Guiry, as manager of its Chicago branch office and warehouse. Mr. Guiry has been connected with the Kennedy Chicago Office for the last 9 yr.

PAUL W. ROMIG, power sales engineer of the Wisconsin Public Service Corp., Green Bay, Wis., was elected chairman of the Great Lakes Power Club, composed of power sales engineers in Illinois, Indiana, Michigan and Wisconsin, at a meeting held at Chicago on April 24. Mr. Romig was vice-chairman of the organization last year, and was elevated to the chairmanship at the recent session.

MANY INTERESTING technical papers and reports are scheduled for the 1936 annual meeting of the A.S.T.M. to be held at Chalfonte-Haddon Hall, Atlantic City, June 29 to July 3. Some twenty sessions are scheduled, one of the outstanding groups of papers being a symposium on X-ray Crystallography and Radiography. Several papers dealing with various phases of spectrographic analysis were on the program and one session will be devoted entirely to water treatment, this session being sponsored by the Joint Research Committee on Boiler Feedwater Studies and the Committee on Water for Industrial Uses. Other technical papers will cover non-ferrous metals, wire, soils, corrosion, fatigue and effect of temperature on metals, cement and concrete.

SALES BILLED BY the General Electric Company for the first quarter of 1936 amounted to $51,423,071, compared with $40,393,538 for the same quarter last year, an increase of 27 per cent, President Gerard Swope announced to the stockholders of the Company at their annual meeting at Schenectady on April 21.

Profit available for dividends amounted to $7,086,830 for the first quarter of 1936, compared with $5,390,931 for the first quarter last year, an increase of 31 per cent. This is equivalent to 25 cents a share for the 1936 quarter and 19 cents a share for the 1935 quarter. The dividend payable to stockholders on April 25th will be at the rate of 25 cents a share, compared with 15 cents a share paid in April a year ago.

Orders received during the first quarter of 1936 amounted to $59,569,879, compared with $49,379,932 for the same quarter of 1935, an increase of 21 per cent.

Orders received for the twelve months ended March 31, 1936, amounted to $227,551,534, an increase of 17 per cent over the twelve months ended March 31, 1935. Net sales billed for the twelve months' period amounted to $219,762,966, an increase of 29 per cent over the corresponding period a year ago.

TUBE-TURNS, INC., Louisville, Ky., has just issued a 48-page catalog and price list No. 107 describing the various fittings which are manufactured under the trade name Tube-Turns and are especially fitted for welded pipe construction.

AMONG RECENT ORDERS for Taylor stokers announced by the American Engineering Co., Philadelphia, Pa., is: one double opposed type designed for a boiler with a normal capacity of 330,000 lb. per hr. for the Detroit Edison Co. and two for 307 hp. and two for 394 hp. boilers to be used by the Timken Roller Bearing Co., in modernizing its present boiler plant.

ANNOUNCEMENT comes from The Bristol Co., Waterbury, Conn., that L. E. Mustard has been appointed district manager of the company's branch office in Detroit. Mr. Mustard started his business career with the Westinghouse Electric and Manufacturing Co., joining the sales and service organization of The Bristol Co. in 1923, and in the years that followed was associated with the Pittsburgh, Denver and St. Louis offices. During the past three years he served as sectional sales and service engineer with headquarters in Dallas, Texas.

APPOINTMENT of John F. Cooke to have charge of the sales of the hoist, pump and marine division of the American Engineering Co., Philadelphia, Pa., has recently been announced by Joseph G. Worker, General Sales Manager. Mr. Cooke joined the company in 1928 after service as an officer in the U. S. Navy.

D. H. SKEEN & COMPANY, One N. La Salle St., Chicago, has been reorganized with Kenneth Williams as president. Mr. Williams, until recently was with Byllesby Engrg. & Mgmt. Corp., and prior to that was with Edgemoor Iron Works for a period of about twelve years. The company will continue to act as sales representatives of power plant equipment.

For the Engineer's Library

POWER OPERATOR'S GUIDE. By E. J. Tangerman. McGraw-Hill Book Co., Inc., New York, N. Y. 1935. Cloth, 6x9 in., 568 pp. Price, $4.

Compilation of 1000 kinks which have been used in power plants for overcoming operating troubles, making repairs, operating equipment and saving expense. In 19 chapters are covered the various equipment of the plant, including the boiler room, generating plant, water system, transmission, piping and buildings services. Many of the devices are illustrated, while a comprehensive index gives quick reference to the various classes of equipment.

DESIGN, CONSTRUCTION AND OPERATION of the Model 33-D Diesel engine is covered in a 30 page bulletin in color just issued by Fairbanks, Morse & Co., 900 So. Wabash Ave., Chicago. This model has oil cooled pistons, open head combustion, differential-injection valves, back flow scavenging and is now available in four different cylinder sizes with ratings as low at 250 hp.

LINK-BELT Co., Chicago, has just printed three new booklets on automatic firing with coal, for boilers up to 300 H.P. Booklet No. 1541 covers the series of automatic coal burners for the home; another (No. 1537) shows applications of Link-Belt stoker firing to commercial heating plants; and the third (No. 1538) covers automatic generation of process steam, high or low pressure. The anthracite series of automatic coal burners, built in Philadelphia, is illustrated in folder No. 1522.

STAYNEW FILTER CORP., Rochester, New York, is distributing its Bulletin 120 dealing with the Staynew Automatic Air Filter, Model A, for all ventilating purposes. This filter is of the continuous type employing the principle of oil impingement.

QUIGLEY Co., 56 W. 45th St., New York City, is distributing a folder giving information on Insulcrete, a light weight insulating refractory cement used for furnace linings, door linings, heat shields, and kindred services.

MANZEL BROTHERS Co., 309 Babcock St., Buffalo, N. Y., has just issued its catalog 25-B, describing Manzel Forced Feed Lubricators for positive and automatic lubrication of cylinders and bearings.

CORNELL ROLLING GRILLES are described in the first complete catalog to be issued on this equipment by the Cornell Iron Works, Inc., 3600 13th St., Long Island City, N. Y. These grilles operate like the more common rolling doors and give equal security without blocking light, air or vision.

WORTHINGTON PUMP & MACHINERY CORP., Harrison, N. J., recently issued a number of new bulletins covering the following equipment: Vertical four-cycle direct-injection Type C Diesel engines; a test sheet for feedwater heaters; Two-stage centrifugal underwriter fire pumps; Freflo centrifugal pumps for underpass drainage; Multi-stage centrifugal pumps, Type UX; Monobloc condensate return units; Monobloc pumping units; Types AA and AC single piston steam pumps for pressures of 75 and 250 lb. respectively.

BULLETIN No. 360-C describes the Pneumatic Sponge built by Byron Jackson Co., Berkeley, Calif. This is a portable, 2½ in. single stage, vertical centrifugal pump driven by an air motor and capable of pumping, from 25 to 125 gal. per min., over a range of from 50 to 150 ft.

VIBRATING COAL SCREENS as built by the Allis-Chalmers Mfg. Co., Milwaukee, Wis., are described in Bulletin 1476 just issued by that company. Three types with the principal features and dimensions are shown.

PARKER APPLIANCE CO., 17325 Euclid Ave., Cleveland, Ohio, has just published its bulletin No. 41 on Parker seamless tubing which not only describes the construction and materials used in this product but gives complete price lists.

DEARBORN CHEMICAL CO., 310 S. Michigan Ave., Chicago, Ill., is distributing an attractive bulletin entitled Let Dearborn Guard Your Boiler Plant which describes briefly and clearly the Dearborn method of industrial boiler water correction.

THE IRON FIREMAN MFG. CO., Cleveland, Ohio, describes its new pneumatic spreader stoker in catalog No. 3905 which has just been issued and is being distributed to engineers interested in this type of equipment. The bulletin is filled with line drawings and detailed photographs which give a clear conception of the construction and operation of this new equipment.

AMERICAN SCHAEFFER & Budenberg Division of Consolidated Ashcroft Hancock Co., Bridgeport, Conn., has issued Bulletin W dealing with American Utility Thermometers for various types of industrial service.

THE PERMUTIT CO., 330 West 42nd St., New York City, has just issued a bulletin entitled Permutit Hot Lime Soda Water Softening Equipment for boiler feedwater conditioning. This is a very attractive bulletin filled with technical data of value to engineers having to do with the operation of boiler plants.

COMBUSTION METERS and instruments as made by The Hays Corporation, Michigan City, Ind., are described in a new 14-page catalog, RA-346.

THE RELIANCE GAUGE COLUMN CO., 5902 Carnegie Ave., Cleveland, Ohio, announces a new 8-page catalog-folder which gives complete information regarding float-operated safety water columns, accompanied by descriptive illustrations. The folder also contains detailed size and price lists, including technical specifications of fittings and installations.

COMMONWEALTH ELECTRIC AND MFG., Co., Boston, Mass., has issued a new price list of their Electric Heated Full-Automatic Steam Boilers. Prices and specifications are given on several new larger sizes not previously listed, as well as new pressure ranges up to 300 lb. per sq. in. steam pressure.

PRACTICAL INSTRUMENT CO., Chicago, Ill., has issued a new folder describing low priced 24 hr. recording instruments. These include a recording thermometer at $18 and an electrical operation recorder at $21.

BULLETINS 213 AND 214 have just been published by Reliance Electric and Engineering Co., Cleveland, O. These describe their Type T Heavy Duty fully enclosed, fan cooled direct current motors. Bulletin 215 and 216 described their Type T-6 pole motors.

BULLETIN 177, issued recently by Allis-Chalmers Mfg. Co., Milwaukee, Wis., is devoted to the merits of their line of high voltage power transformers.

METAL-CLAD SWITCHGEAR is the subject of GEA-1661A (superseding GEA 1661) a 12 page bulletin issued by General Electric Co., Schenectady, N. Y.

FACTS FOR USERS OF A. C. MOTORS is the title of a folder issued by The Lincoln Electric Co., Cleveland, O. It gives ratings, dimensions and prices on the various sizes and types.

LEAFLET 2228 just issued by Allis-Chalmers Mfg. Co., Milwaukee, on their Laboratory Model, metal-tank, mercury arc power tube is intended for limited distribution, primarily to colleges and universities.

STANDARD HAND BOOK of Refractories has been published as a 52 page Bulletin No. 37 by the Standard Fuel Engineering Co., 667 So. Post Ave., Detroit, Mich. It contains information about refractories, refractory cement, furnaces and, in tabular form, data on standard and special shape bricks, blocks and tiles.

DIESEL, THE MODERN POWER, is the title of a new 31 page booklet published by the Research Laboratory Section of the General Motors Corp., Detroit, Mich. The book covers in a simple way fundamentals of engine construction and operation.

MODERN STEAM ENGINES,—construction, design and application, with tables of size, water rates and pertinent data regarding horizontal and vertical engines are covered in a 48 page booklet just issued by the Troy Engine & Machine Co., Troy, Pa.

BROWN INSTRUMENT CO., Philadelphia, Pa., is distributing a new booklet illustrating and describing the part played by instruments and control in modern industrial plants, taking up the subject from the viewpoint of the executive in charge of plant operation and production. The company is also distributing a folder entitled Modernization—The Trend in Industry which deals principally with the application of Brown potentiometer pyrometers.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has published a new 70 page illustrated Bulletin No. 1652 covering Hydraulic Turbines and Auxiliaries, including the Boulder Dam Turbines. A copy will be mailed to interested engineers and executives who make their request on official stationery.

DESIGNED to serve air and gas compressors of moderate capacities, a new pipe line aftercooler is described in a new 4-page folder of the Ingersoll-Rand Co., 11 Broadway, New York City.

SOME OF THE PRODUCTS of The Babcock & Wilcox Co., 85 Liberty St., New York, are described in three new bulletins. Bulletin G-17-A covers the integral-furnace boiler, giving arrangement drawings, construction, performance and typical installations. The second bulletin covers five insulating fire bricks and includes thermo conductivity curves and typical wall construction. The third bulletin covers refractories, mortars and plastics.

REDLER CONVEYOR ELEVATORS for handling coal and similar bulk materials are described in a new 36 p. bulletin issued by Stephens-Adamson Mfg. Co., Aurora, Ill. This covers typical installations, capacity tables and charts, and construction of the equipment. These elevators convey and elevate in any direction, they are totally enclosed and may be arranged to discharge at any point.

COMPARISON OF MUNICIPAL and Company Rates based on the Electric Rate Survey of the Federal Power Commission with supplementary equipment is included in a recent 20 p. publication of the Edison Electric Institute, 420 Lexington Ave., New York. This bulletin will be sent to interested parties upon request. According to the report the most interesting aspect of the Electric Rate Survey of the Federal Power Commission has been the confirmation of the fact that privately operated utilities have, on the average, lower rates for electricity than the municipal plants.

INSTRUMENTS manufactured by the Hays Corp., Michigan City, Ind., and engineering data on their application are included in a 14-page bulletin just issued by that company.

METAL STATISTICS, 1936, published by American Metal Market, 111 John St., New York. Size, 4 by 6 in., 505 pp. Price $2.
This is the 29th annual edition and presents reliable figures on the production and consumption of ferrous and non-ferrous metals with additional statistics on miscellaneous economic subjects of interest and value to members of these and related industries.

SYMPOSIUM ON INDUSTRIAL FUELS is a reprint of four papers presented at a joint meeting of the A.S.T.M. and the Engineers' Club of Philadelphia in the latter part of January, 1936. These papers cover coal and coke, industrial fuel oils, manufactured gas and liquefied petroleum gas. The paper bound booklet contains 70 pages and can be obtained from the A.S.T.M. headquarters, 260 South Broad St., Philadelphia, Pa. Single copies are 75 cents each, orders of ten or more copies, 60 cents each.

ALLIS-CHALMERS MFG. CO., Milwaukee, Wis., has just published a new 24 page booklet describing in detail its Model L tractor.

BULLETIN 22-B12, devoted to the application of Rotary Positive Blowers in foundry cupola service, has just been issued by the Roots-Connersville Blower Corp., Connersville, Ind.

A 4-PAGE CIRCULAR, known as section 521, issued by Condit Electrical Manufacturing Corp., Boston, Mass., describes the new Condit DZ-40 Ruptor-equipped, indoor, station type oil circuit breaker of 100,000 kv-a. interrupting capacity for 15,000 v. service or less.

Power Plant Construction News

Calif., Burbank — Lockheed Aircraft Corporation, 1705 Victory Place, plans installation of electric power equipment for factory service in connection with expansion and improvements in plant, including new building units for increased capacity. Entire project is reported to cost over $200,000. Financing is being arranged.

Calif., Los Angeles—Balboa Brewing Co., 1834 North Main Street, plans installation of electric power equipment, mechanical-handling and other machinery in new two-story plant addition, to be used for bottling and other operating service. Entire project will cost close to $200,000. Wayne D. McAllister, 1709 West Eighth Street, is architect.

Calif., Los Angeles—Studebaker Pacific Corporation, Central Manufacturing District, plans installation of electric power equipment in new plant additions for production of automobile bodies. Entire project will cost close to $800,000. Company is a subsidiary of Studebaker Corporation, South Bend, Ind. C. K. Whittaker is president of first noted company.

Calif., San Diego—San Diego Consolidated Gas & Electric Co., has authorized fund of $930,000 for extensions and improvements in power plants and system during present year, including installation of station equipment, power substation and service facilities. Company engineering department is in charge.

Conn., East Hartford—United Aircraft Corporation plans installation of electric power equipment for factory service in new one-story addition to local plant of Pratt & Whitney Aircraft Co., an affiliated interest, to be used by Hamilton Standard Propeller Division, another subsidiary. Unit will total 100,000 sq. ft., floor space, and cost close to $200,000. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer.

Fla., Fernandina—Container Corporation of America, Inc., 111 West Washington Street, Chicago, Ill., plans construction of a power plant in connection with new kraft pulp and paper mill in vicinity of Fernandina, where site has been selected. Electric power equipment will be installed for mill service. Entire project will consist of several large units, estimated to cost close to $5,000,000, including machinery. George F. Hardy, 305 Broadway, New York, is engineer.

Ill., Chicago—Acme Industrial Co., 413 North Carpenter Street, plans installation of electric power equipment for factory service in new one-story diemakers' machine works at Union and Lake Streets, 150x150 ft. Entire project will cost about $100,000. Alfred S. Alschuler, 28 East Jackson Boulevard, is architect.

Kan., Iola—United Brick & Tile Co., plans installation of power equipment and mechanical-handling machinery in connection with proposed rebuilding of portion of local plant, recently destroyed by fire. Loss close to $100,000, with machinery.

Md., Salisbury—Eastern Shore Public Service Co., Salisbury, is arranging fund of about $700,000 for extensions and improvements in power plants and system during present year, including installation of new equipment. New transmission and distributing lines will be built, with power substation and service facilities.

Mich., Detroit—Chrysler Corporation, 341 Massachusetts Avenue, plans installation of electric power equipment for factory service in new machine works addition to local automobile manufacturing plant on East Jefferson Avenue. Entire project will cost close to $450,000. Albert Kahn, Inc., New Center Building, city, is architect and engineer.

Mich., Detroit—Federal Engineering Co., 2519 Bellevue Avenue, plans installation of electric power equipment in new two-story mechanical works on Oakman Boulevard, 100x350 ft. Entire project will cost over $100,000.

Minn., St. Paul—Brandtjen & Kluge, Inc., Blair and Gautier Streets, plans installation of electric power equipment for factory service in new two-story addition to printing press manufacturing plant. Entire project will cost close to $80,000. Allan C. Fleischbein, Endicott Building, is architect. Work is scheduled to begin soon.

Mo., Campbell—Common Council is considering extensions and improvements in municipal electric power plant, including installation of additional equipment. Estimates of cost are being made. H. V. Sewall, mayor, is active in project.

Mo., Hannibal—International Shoe Co., 1505 Washington Street, St. Louis, Mo., plans installation of electric power equipment for factory service in new addition to branch plant at Hannibal. Entire project will cost over $200,000.

Nev., Mountain City—Mountain City Copper Co., plans installation of electric power equipment in new 300-ton flotation mill, for which superstructure will soon be placed under way. Cost close to $400,000, complete. Company is a subsidiary of Anaconda Copper Mining Co., 25 Broadway, New York, N. Y.

N. J., Woodbine—Common Council has authorized estimates of cost for a new municipal electric light and power plant. A committee has been appointed, headed by William Abramson and C. P. Wood. Different types of equipment will be investigated.

N. Y., Niagara Falls—Union Carbide Co., 137 Forty-seventh Street, plans installation of electric power equipment in connection with extensions and improvements in plant, including new buildings and machinery for increased output. Cost close to $1,000,000. Company is a unit of Union Carbide & Carbon Corporation, 30 East Forty-second Street, New York, N. Y.

N. Y., Northport—Construction Service, Veterans' Administration, Washington, D. C., will receive bids until June 16 for boiler plant equipment, refrigeration machinery, steam distribution system, electrical distribution system and other utilities in connection with new buildings at institution at Northport, L. I., for which general erection bids are asked at same time, as per plans and specifications on file.

N. D., Minot—Northern States Power Co., Minneapolis, Minn., has approved plans for extensions and improvements in steam-electric generating plant at Minot, including installation of new boiler unit and other equipment. Work scheduled to begin at early date. Cost about $100,000.

Ohio, Youngstown — Youngstown Sheet & Tube Co., plans extensions and improvements in power plant at local Campbell mill, including installation of new turbo-generator unit and auxiliary equipment. Cost close to $350,000. Work is scheduled to begin at early date.

Okla., Stillwater—Common Council plans extensions and improvements in municipal electric generating plant, including installation of new turbo-generator unit and accessory equipment. Fund of about $80,000 is being arranged for work.

Pa., Bradford—Kendall Refining Co., has authorized extensions and improvements in power plant in connection with expansion program at local oil refinery, including installation of new electric-generating equipment, boiler units and accessories. Entire project, including refinery enlargement, will cost over $1,000,000 and will require close to one year for completion.

Pa., Oil City—Keystone Public Service Co., has approved fund of about $350,000 for extensions and improvements in local steam-electric generating station, including installation of new prime mover and auxiliary equipment, to represent about $300,000 of gross amount noted. Work is scheduled to begin at once.

Tenn., Columbia—Monsanto Chemical Co., 1700 South Second Street, St. Louis, Mo., plans power plant at proposed new phosphate treating and refining plant near Columbia, where tract of phosphate land has been acquired. Electric power equipment will be installed for mill service. Entire project is reported to cost over $500,000. Financing is being arranged. Company will also expand power plant and facilities at Monsanto, Ill., works, to cost in excess of $100,000.

Texas, Houston — Continental Can Co., plans installation of electric power equipment for factory service in new addition to local plant. Work will begin in near future. Entire project will cost about $250,000. Robert J. Cummins, Bankers' Mortgage Building, Houston, is engineer. Company headquarters are at 100 East Forty-second Street, New York, N. Y.

Texas, Perryton — Common Council has plans under way for new municipal electric power plant, using Diesel engine-generator units and accessories. Fund of $150,000 is being arranged for new plant and electrical distribution system. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Va., Alexandria — Virginia Public Service Co., Charlottesville, Va., plans additions and improvements in steam-operated electric generating plant at Alexandria, including installation of new equipment for increased capacity. Estimated cost about $500,000. Proposed to begin work soon.

Wash., Seattle—Casein Mfg. Co., Inc., Seattle, manufacturer of glue, adhesives, etc., plans installation of electric power equipment for factory service in connection with proposed rebuilding of portion of local plant, recently destroyed by fire. Loss over $100,000, including equipment. Company is affiliated with Borden Co., 350 Madison Avenue, New York, N. Y.